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ON THE IDENTIFICATION, DISTRIBUTION, AND BIOLOGY OF THE DOLPHINS, *CORYPHAENA HIPPURUS* AND *C. EQUISELIS*[1]

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ABSTRACT

Coryphaena hippurus, the common dolphin, and *C. equiselis,* the pompano dolphin, have been studied. The specific name *equiselis* is considered valid, as opposed to the emended form, *equisetis.* The two species differ markedly in numbers of dorsal and anal rays and lateral-line scales, in morphometric characters which reflect depth, in relative heights of dorsal and anal fins, in the shape of the tooth patch on the tongue, and in the color pattern and head spination of the young. Weights of males and females are similar below about 950 mm, after which males appear heavier. Both species are probably cosmopolitan in warm seas. *C. hippurus* is most often caught in waters over 70°F. Adults of *C. equiselis* are seldom caught and are probably more pelagic and more tropical. *C. hippurus* breeds in summer in the Gulf Stream, earlier in the Caribbean. Young *C. hippurus* are, paradoxically, less abundant than those of *C. equiselis,* particularly in the Gulf of Mexico and Florida Current. The sex ratio of *C. hippurus* is 50:50 in the Gulf Stream, but females apparently predominate in Caribbean sport catches. Stomach analyses show fishes to be the most abundant item in the diet of *C. hippurus,* with no evidence of selectivity. There is some indication that feeding is inhibited at night.

INTRODUCTION

The family Coryphaenidae comprises a single genus, *Coryphaena* Linnaeus, which contains two presently recognized species. *C. hippurus* Linnaeus is cosmopolitan in tropical and subtropical waters and is a well-known food and game fish in much of its range. *C. equiselis* Linnaeus is relatively little known, but is probably also cosmopolitan in much the same waters. The exact distributional status of the latter

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is difficult to determine because it has been confused with its congener. Those who have purported to recognize two species have either cited poor differentiating characters or have considered as *C. equiselis,* females and young males of *C. hippurus,* which lack the high, vertical forehead, and have relegated to *C. hippurus* only the larger males, which have the vertical head profile. Thus it is difficult to determine whether reports of *C. equiselis* are, indeed, that species. An example is found in Barnhart (1936), in which the illustration of *"Coryphaena equisetis"* shows a *C. hippurus* (possibly a female) without the vertical forehead.

The present paper has the following objectives: to facilitate the identification of the two species of dolphin, at least as they occur in the western north Atlantic, at any size above about ten millimeters (the smallest size at which specimens of both species were available to us), to clarify their nomenclature, to show relative growth patterns of the two species, to indicate the distribution of both young and adult in the Atlantic, and to contribute to the biology of both species by giving data on spawning and food habits. It is hoped that this information will provide a basis for future, more-detailed studies of both species, and of *C. equiselis* in particular.

Nomenclature

Linnaeus described both *Coryphaena hippurus* and *C. equiselis* in the 10th edition of Systema Naturae (1758:261). Whereas other nominal species have been described, at the present time none of these seem justified.

Although the name *equiselis* was used by Linnaeus in his work, this has long been considered a misprint, and *equisetis* has been used instead. Osbeck (1757:308), from whose work the Linnaean description and name were apparently derived, did, indeed, use the name *equisetis*. On the other hand, Linnaeus' "misprint" was not corrected in three editions of Systema Naturae following the tenth. Furthermore, as Fowler (1906:122) pointed out, neither form is incorrect from an etymological standpoint. There is no decisive evidence that the Linnaean form was not intentional. We therefore believe that the name should stand as *Coryphaena equiselis* Linnaeus, 1758.

Coryphaena hippurus is properly termed "dolphin," even though this name is also applied to certain cetaceans. *C. equiselis* may be known as "pompano dolphin," in reference to the deep body of adults.

Materials and Methods

Most of our data is derived from material from two regions: from the Gulf of Mexico and the Gulf Stream. Many small specimens were collected by Harvey R. Bullis, Jr. of the U. S. Fish and Wildlife Service and the crew of the M/V OREGON. We are indebted to Mr. Bullis, not only for the specimens, but also for permission to participate personally in a cruise aboard the OREGON. Edgar L. Arnold, Jr. of the Fish and Wildlife Service contributed other Gulf specimens. From the region of the Gulf Stream (*sensu stricto*, cf. Iselin, 1936:74), most of our specimens were collected from the M/V DELAWARE. We are grateful to James L. Squire, of the Fish and Wildlife Service, for allowing us to participate in several cruises. Members of the crews and scientific personnel of the research vessels ATLANTIS, CRAWFORD, BEAR, and CARYN, of the Woods Hole Oceanographic Institution, collected specimens from the Gulf Stream, the Caribbean Sea, and the tropical Atlantic. We are especially grateful to W. Scott Bray, Richard H. Backus, Dana Densmore, Robert A. Lufburrow, and Nicholas Rosa for these specimens. W. W. Anderson and Jack W. Gehringer kindly loaned us the specimens collected in the Florida Current and Bahamas region by the Fish and Wildlife M/V THEODORE H. GILL. We extend our thanks for Rockport, Texas, specimens to Patricia Pew of the Texas Game and Fish Commission; for Woods Hole specimens to Nadine Athearn; and for specimens in their collections, to Reeve M. Bailey of the Museum of Zoology, University of Michigan, Royal D. Suttkus of Tulane University, and ichthyologists at the Museum of Comparative Zoology and the U. S. National Museum. Edward C. Raney and William C. Schroeder critically read the manuscript. We are particularly indebted to Frank J. Mather III, of the Woods Hole Oceanographic Institution, for allowing us to use his unpublished data and preserved material, to Donald S. Erdman of Lajas, Puerto Rico, for information on *C. equiselis* in Puerto Rico, to Donald P. deSylva of the University of Delaware, Bayside Laboratory, for reading the manuscript and contributing information on the coloration of *C. equiselis* and on other phases of the work. All figures are the work of G. G. Pasley.

Five counts (dorsal, anal, pectoral rays, lateral-line scales, gill rakers) were made routinely. The dorsal, anal, and pectoral counts include all elements, both spines and rays. In the dorsal fin, it is difficult to determine how many, if any, of the anterior elements are spines.

In the anal fin, we found one to three spines preceding, and usually considerably shorter than, the rays, although there was usually a single, slightly shorter ray preceding an otherwise rather uniformly graded series. There was one pectoral spine. The pelvic fins were almost constantly I, 5, and we did not enumerate this beyond an initial check. Lateral-line scales are extremely difficult to count, as there is no well-arranged pattern of vertical or horizontal rows. We counted either pores in or scales above or below the lateral line. This count is probably not precise, but even so its value is seen in the species comparison, where it provides almost complete separation. Because of the range, it was necessary to present the results in groups of five, which then show a relatively normal distribution. Gill rakers were counted without including rudiments. Even in the younger specimens (ca. 10 mm) there were rough patches at the ends of the gill bar which could have been construed as remnants. Since these occurred in our smaller specimens, it was concluded they did not represent reduced rakers.

Measurements were taken in accordance with Hubbs and Lagler (1947). Those not listed by them are self-evident or are explained in the appropriate place. Dial calipers were used on all small specimens, and, on large specimens, calipers constructed of specially made headpieces on a meter stick. Most of the latter were measured at sea and the specimens not retained.

Weights were taken by the authors on fresh specimens caught well out at sea. Ship's motion usually prevented precision beyond the nearest pound. Further weights were contributed by Mather, and others were taken from the literature. Preserved specimens were not weighed.

We have routinely used standard length as a basis for comparisons and this is used throughout this paper except where expressly stated otherwise (as in length-weight, where we used the data of others who did not use standard length).

Coloration

The color of living *C. hippurus* can only be described as superbly beautiful; detailed comments are never quite adequate to convey this impression. Swimming free in the water, *C. hippurus* is commonly a rich, almost turquoise blue in general coloration, with tinges of yellow. Often individuals have been seen which displayed vertical bands, and on occasion this pattern has been observed to disappear and reappear at short intervals. Such a banded pattern has never been noted by us in a landed fish. A freshly-caught specimen changes color very rapidly;

yellow is usually the predominant shade, but much turquoise blue is seen at first. After death, these colors fade to leave the fish uniformly silvery.

The coloration of freshly-caught adults of *C. equiselis* has not been observed by us, but is said to resemble closely that of *C. hippurus,* with more silvery, instead of yellow, hues. The black spots on the sides are supposedly more noticeable in *equiselis,* particularly shortly after death, and the dorsal, anal, and caudal may have more yellow. This does not agree with preserved adults, which are rather uniformly dark, or with the young, which are discussed below.

The young of the two species are distinctively patterned. This enables their identification without reference to counts or measurements in almost all cases, from the smallest we have seen (ca. 9 mm) to about 200 mm, and perhaps larger. The principal differences are in the pattern of the sides and of the dorsal, anal, pelvic, and caudal fins.

Young of *C. hippurus* (see Fig. 1, upper) tend to have the entire sides of the body marked with a pattern of alternating dark and light bars. This is particularly evident at very small sizes (10-20 mm standard length), where specimens with erected dorsal and anal fins resemble miniature feathers. The bars are continued onto the dorsal and anal fins, except for the rear rays of each, where the dark coloration forms a more or less solid patch. We have observed this general pattern in individuals slightly more than 100 mm long. At larger sizes, however, the bars become more obscure, and are lacking in many specimens. Such specimens are similar to *C. equiselis* in this respect.

C. equiselis (see Fig. 1, lower) when very small tends to be uniformly dark on the sides. The fins, while sometimes displaying weak bars, never show these as prominently as *C. hippurus.* Ordinarily the dorsal fin is relatively clear, often having, in addition to any weak bars, a concentration of pigment near the middle of the fin and in the posterior membranes. The anal fin is quite clear except for a posterior darkened area.

The pelvic fin of *C. hippurus* is usually dark, while that of *C. equiselis* is clear.

Most consistent of all is the pattern of the caudal fin. In young of *C. hippurus* the fin is pigmented except for the tips of each lobe. In *C. equiselis* the unpigmented region extends in a band along the entire margin of the fork. In some small specimens of this species almost the entire fin may appear clear, but the pigment present usually has an

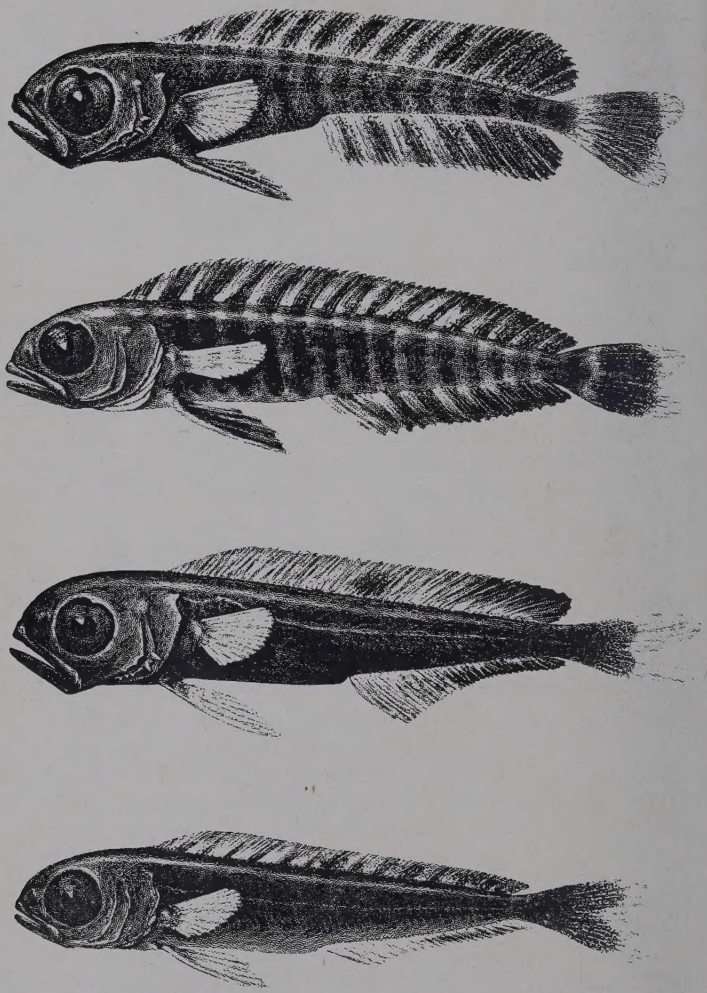


FIGURE 1. Upper 2, *C. hippurus*. Lower 2, *C. equiselis*. Upper figure of each species was drawn with modifications from specimens ca. 15 mm standard length from M/V OREGON station 1298 in the northern Gulf of Mexico; lower figures from specimens ca. 35 mm from OREGON station 1313 in the northern Gulf and from 12°00′ N, 76°00′ W (R/V CRAWFORD collection), respectively.

emarginated posterior border. At around 200 mm this caudal fin pattern becomes obscure, and it is absent from larger adults of both species.

Head Spination

The head region of both *C. hippurus* and *C. equiselis* is characterized by the presence of sphenotic (SPH) and supratemporal (ST) spines, by a double series of preopercular spines (POPa and POPb), by a mandibular or angular spine (A), and by a supraorbital spine (SO) (Fig. 2).

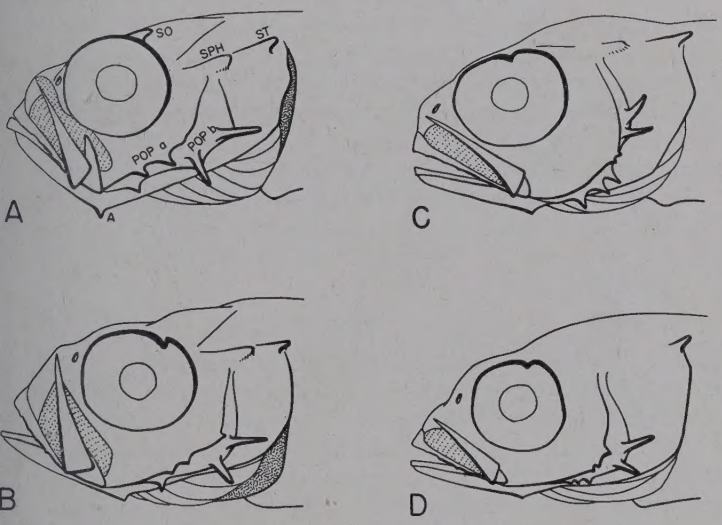


FIGURE 2. Heads of *Coryphaena* showing spination. A and B, *C. hippurus,* standard length 13.8 and 16.6 mm, respectively. C and D, *C. equiselis,* 13.3 and 16.5 mm, respectively.

In *C. hippurus,* the series of spines are all present in a 10.5 mm specimen, the smallest that could be satisfactorily examined. The sphenotic spine is thick and moundlike in appearance. The supratemporal spine is small but sharp, and is located at the angle of the opercular slit. In the anterior preopercular series there are two small spines below the angle, and a third may or may not be present at the angle. In the posterior preopercular series there are two groups. The upper and most prominent is a pair of long, divergent spines which reach well across the opercle. Below these, and anterior to the first series, is a single

small spine (sometimes two). The angular spine is blunt and not always prominent. The supraorbital process is quite conspicuous on the upper posterior part of the orbit. The position of these spines remains fairly constant, but their relative size decreases as the size of the fish increases. By 25 mm POPa and the smaller POPb have almost disappeared. SPH is a welt at this size, and ST is very short. At 35 mm the spines may all be observed as tiny points except the larger POPb, which are not considerably less prominent than before. By 38 mm only the larger POPb may be seen, and these are now mere tips. Thus by about 40 mm little or no trace of head spination remains in this species.

The arrangement of spines is similar in *C. equiselis,* but there are differences in number and development. The lower series of small POPb spines usually numbers three, instead of one or two, and SO and SPH are comparatively poorly developed. SO disappears by about 19 mm. POPa and the lower, smaller POPb gradually are reduced and by about 24 mm are no longer evident. ST is no longer observable by about 30 mm, and the strong POPb disappear by about 35 mm.

The fact that the spines lose their identity in *C. equiselis* at a smaller size than in *C. hippurus,* may be correlated with the earlier maturity of the former.

Tongue Teeth

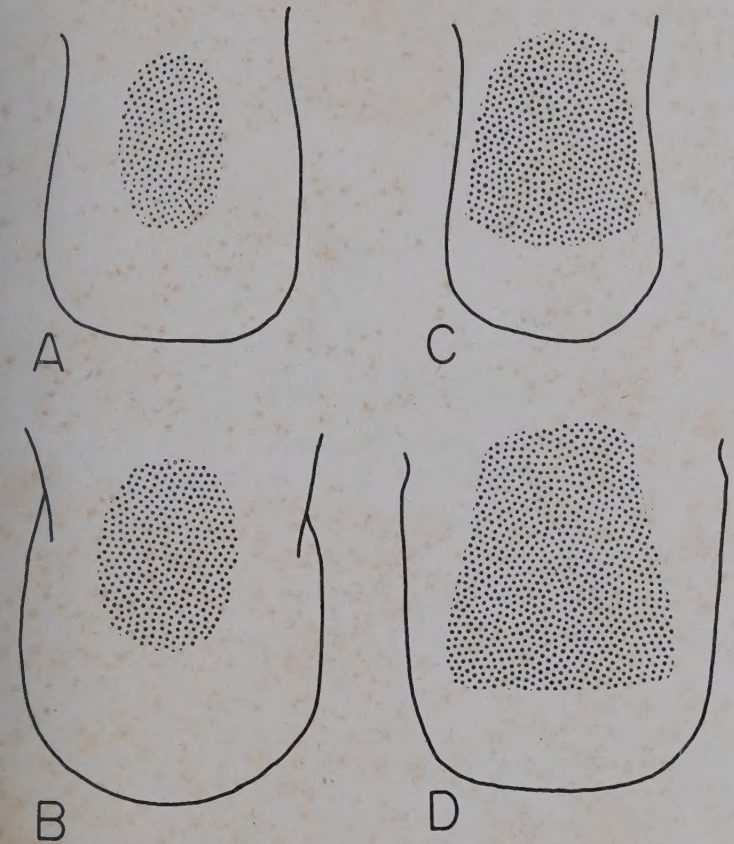
Nichols (1909) compared the two species and noted differences in the tooth patches on the tongue. Fig. 3 shows the typical situation in intermediate and larger specimens. In *C. hippurus,* the patch is usually ovoid and covers the center half of the width of the tongue. In *C. equiselis,* the patch is somewhat trapezoidal, with angular edges, larger in front than behind, and covers most of the width of the tongue.

In specimens smaller than about 75 mm the patch tends to be less well-defined and is thus no longer reliable as a means of identification.

Meristic Characters

These characters are quite difficult to use, but they provide excellent means for differentiating the species of *Coryphaena.* Table 1 and Figs. 4 and 5 show the frequency distributions.

Dorsal-fin elements (Fig. 4) have usually been the common differentiating character. Obviously, however, few specimens were examined, for the separations were deceptive, of the order of "around 55 vs. around 60." Great care must be taken in counting the most anterior elements, particularly in large specimens, where they must be dissected.



IGURE 3. Dorsal surface of tongue of *Coryphaena* showing tooth patches. A nd B, *C. hippurus,* standard length 223 mm and 420 mm, respectively. C and), *C. equiselis,* 205 and 435 mm, respectively.

When this precaution is taken, most specimens with 55 or fewer dorsal lements are *C. equiselis,* those with 56 or more, *C. hippurus.* In our tudy, 87.3% of *C. hippurus* are separable from 94.4% of *C. equiselis* y this count, for an index of divergence (Ginsburg, 1954) of 90.4.

Anal elements (Table 1) are less reliable, although their frequency istributions do not coincide. *C. equiselis* usually has 27 or fewer lements, *C. hippurus* 26 or more, but there is considerable overlap,

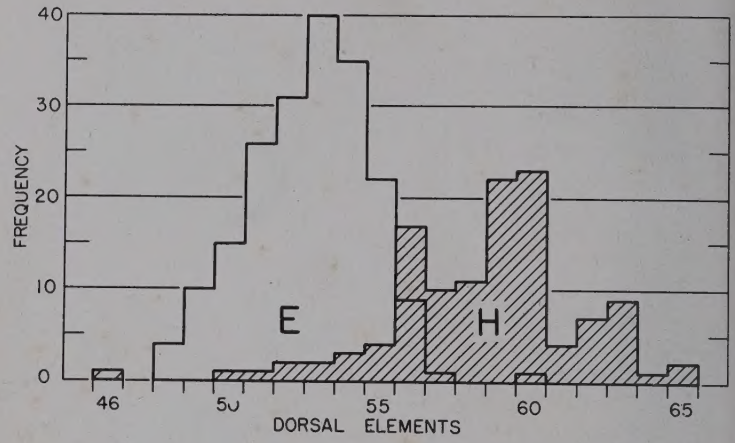


FIGURE 4. Number of dorsal rays in *C. equiselis* (E, open bars) and *C. hippurus* (H, crosshatched bars).

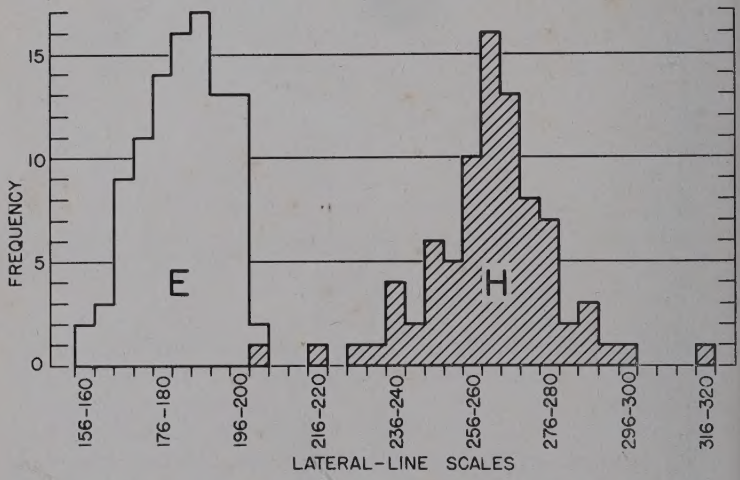


FIGURE 5. Number of lateral-line scales in *C. equiselis* (E, open bars) and *C. hippurus* (H, crosshatched bars).

articularly on 26 and 27 elements. The index of divergence here is nly 79.8.

Pectoral rays (Table 1) are usually 19 or 20 in either species. Pelvic lements are almost invariably I, 5.

TABLE 1

FREQUENCY DISTRIBUTION OF SOME MERISTIC CHARACTERS OF CORYPHAENA IN THE ATLANTIC OCEAN

C. hippurus Gill Rakers

	upper			lower						total							
	0	1	2	7	8	9	10	11	12	8	9	10	11	12	13	14	15
nall	—	36	14	—	1	17	24	7	1	—	—	1	13	22	10	3	1
termediate	1	2	—	—	3	—	—	—	—	—	1	2	—	—	—	—	—
rge	67	3	—	23	42	5	—	—	—	23	40	7	—	—	—	—	—

C. equiselis Gill Rakers

	upper			lower					total					
	0	1	2	3	8	9	10	11	9	10	11	12	13	14
nall	3	131	51	1	12	93	67	14	1	11	75	59	33	7
termediate	—	5	—	—	—	5	—	—	—	—	5	—	—	—
rge	4	4	—	—	4	4	—	—	3	3	2	—	—	—

	Anal Elements								Pectoral Elements				
	23	24	25	26	27	28	29	30	17	18	19	20	21
. *hippurus*	—	—	2	24	49	42	9	1	1	5	37	76	4
. *equiselis*	5	24	62	86	38	6	1	—	—	3	62	124	8

The number of lateral-line scales (Fig. 5), while somewhat difficult o count, affords the best means of differentiation. Of a total of 183 pecimens, only three overlap. For practical purposes *C. equiselis* has 00 or fewer scales, *C. hippurus* more than 200. Most *C. equiselis* ll between 170-200 (mean 183.5), most *C. hippurus* between 245-80 (mean 262.8).

The gill-raker counts (Table 1) show no evident species differences xcept for a slightly lower mode for those on the lower arch of *C. quiselis*. There is, however, an obvious reduction in number with age. his is particularly notable in *C. hippurus*, where enough adult counts re available to afford reliability. There was little question in this study s to which specimens were considered as adults. We have few speci-ens in a wide gap between small (less than 150 mm) and large (300 m and over) specimens (see graphs, Figs. 6-9). Most young have ne or two rakers on the upper limb of the arch, one in the middle, nd nine or ten on the lower limb. The adults have no rakers on the

upper limb, one in the middle, and only seven or eight (or nine in *C. equiselis*) on the lower limb. Thus the total raker count is usually 8 or 9 (or 10 in *C. equiselis*) in adults, 11 or 12 in young of both species.

Relative Growth

Twenty measurements, in addition to standard and fork lengths, have been used in this study. Of these the ten discussed below and shown in Figs. 6, 7, and 9 indicate species differences in proportions, either as young or adult or both. The remaining ten, which do not show interspecific differences, are shown in Fig. 8. In examining these graphs, it should be remembered that *C. equiselis* presumably does not attain as large a size as *C. hippurus;* our largest specimen of the former was 447 mm standard length, of the latter over 1200 mm. Each graph includes one or more reference lines. These are not intended as regression lines, but partly as indications of the linearity of the plotted points and partly as rough indications of the relative size of the given part. The indicated proportions are that of the part compared to standard length.

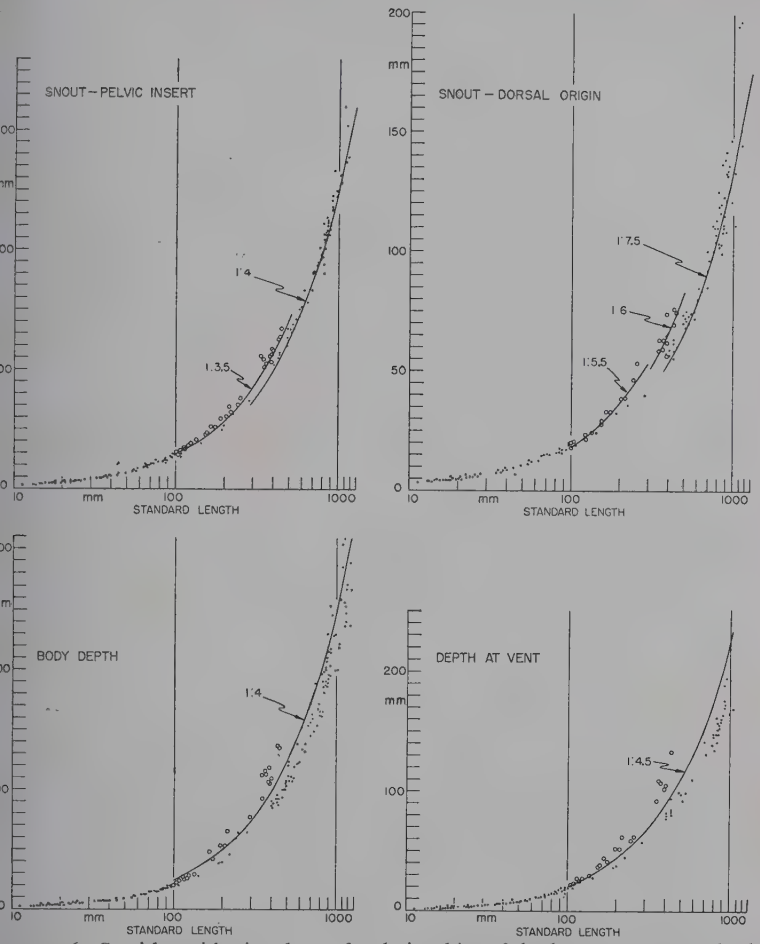
Most measurements are quite uniform in their changes with growth. On semi-logarithmic paper, plotted against standard length, their points form a wide hyperbolic curve. On non-logarithmic paper this would in most cases be nearly a straight line. Only orbit length shows appreciable scatter of points. This is probably due to the small magnitude of the dimension, together with the difficulty of accurately measuring the bony orbit.

The following, which show specific distinctions, are considered individually.

Body depth (Fig. 6). Up to about 100 mm both species are similar in this character. At this point, they gradually diverge, so that by about 200 mm the depth in *C. hippurus* is less than 25% of the standard length, that in *C. equiselis* 25% or usually greater. Exactly where the 25% rule can be applied with certainty is not evident, but care should be taken with specimens under 200 mm. Generally we can say that the greatest depth enters the standard length 4 times or more in *C. hippurus* over 200 mm and less than 4 times in *C. equiselis* of the same size.

Depth at vent (Fig. 6). As in body depth, this character shows divergence between the species only in specimens larger than 100 mm. A line indicating a ratio of 1:4.5 separates most of the available specimens of the two species over 100 m., *C. equiselis* being deeper.

Caudal peduncle depth (Fig. 7). There is no sharp demarcation in



IGURE 6. Semi-logarithmic plots of relationship of body parts to standard ength showing differences in *C. hippurus* (dots) and *C. equiselis* (open circles). elow 100 mm, all specimens are represented by dots. Lines indicate ratio of ody part to standard length and are intended as guides, not necessarily as re-ression lines (see text).

his measurement, but specimens 350-500 mm appear separated. This ollows the trend of the first two characters, *C. equiselis* being deeper. *lead depth at occiput* (Fig. 7). This measurement was made on few

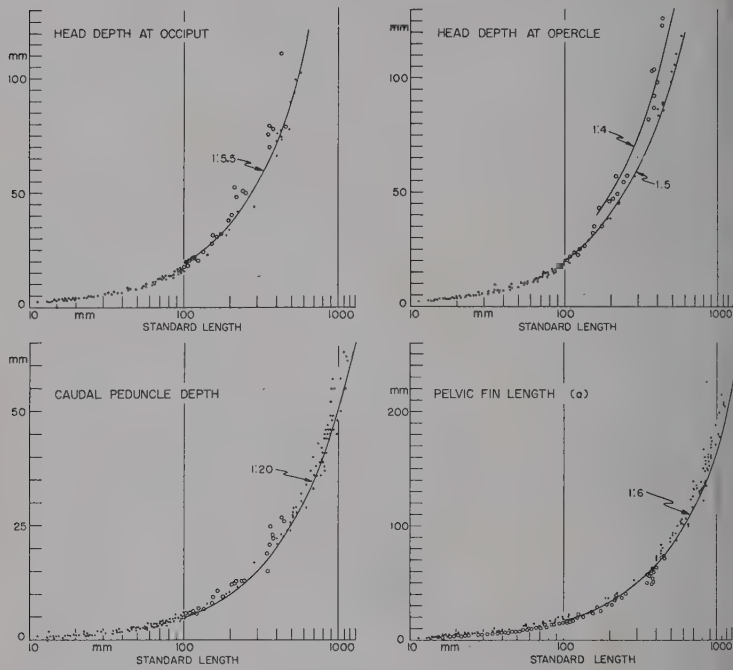


FIGURE 7. See legend for Fig. 6.

and mostly smaller specimens, but it seems to indicate a greater depth of head in larger *C. equiselis*. Again this follows the trend mentioned above. Where mature males of *C. hippurus* with vertical foreheads enter the picture, there is probably a reversal, but such data were, unfortunately, not gathered. Changes in head shape with growth in both species were shown by Lütken (1880).

Depth at opercular margin (Fig. 7). Like the last character, few and mostly small specimens were measured. The opercular margin is near the point of greatest depth in *C. hippurus,* whereas in *C. equiselis* the greatest depth is farther back. Again *C. equiselis* is deeper, but no measurements were made in the size range which would include the bull-headed males.

out to dorsal-fin origin (Fig. 6). In part, this is a reflection of depth. the size range for which specimens of *C. equiselis* are available, this ecies is deeper than *C. hippurus*. Above that size in *C. hippurus*, ost larger measurements are of bull-headed males, which is an indi- tion of the vertical forehead limited to that sex.

out to pelvic insertion (Fig. 6). As with the last character, *C. equi- is* is deeper.

It is noteworthy that in measurements of horizontal distance, no fferences were found. This was true for head length, snout to pec- ral-fin insertion, snout to anal-fin origin, and pectoral-fin insertion anal origin. Thus the different appearances of *C. equiselis* and *C. ppurus* seem to be due entirely to depth differences, and not at all elongation.

lvic-fin length (Fig. 7). The pectorals appear equal in length in both ecies. The pelvics, on the other hand, are longer in *C. hippurus* from standard length of about 20 mm and larger. This is the one differ- tiating character which holds in both young and adults. A line indi- ting a fin length: standard length ratio of 1:5.5 is effective in separat- g specimens less than about 100 mm (Fig. 8). Because of lack of *hippurus* of intermediate size, little can be said for the area between 0 and 350 mm. In specimens over 350 mm, a ratio of 1:6 effectively parates the two species.

orsal and anal-fin heights (Fig. 10). These characters must be nsidered from two standpoints: the greatest height of each fin and e relative height of anterior and posterior parts of the same fin. Up about 20 mm, it is difficult to detect differences in either respect. In rger specimens, *C. hippurus* has a decidedly higher dorsal fin, and a nsiderably higher anal fin. It is emphasized by the fact that in young *C. hippurus* the fins tend to be erected in preservation, and are nspicuously marked by bars. In *C. equiselis* the fins more often are ostrate, and seldom have a barred pattern.

The relative heights of the anterior and posterior parts of the fins ffer in the two species. *By height, we mean the length of the rays,* t necessarily the vertical height of the fin. Ordinarily the longest sterior rays are inclined rearward, so that the fin may not appear as gh posteriorly, but the rays may be longer. The height of the dorsal s the length of the longest ray taken approximately 10-15 rays from e origin.

In *C. hippurus,* there is comparatively little gradation in the height the dorsal fin, although the posterior part tends to be slightly higher.

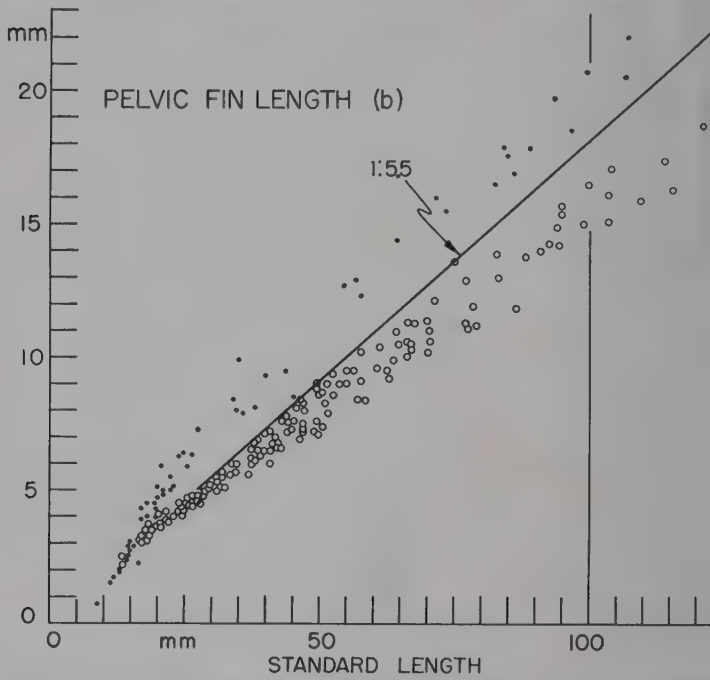


FIGURE 8. Pelvic-fin length shown on a non-logarithmic scale to emphas completeness of separation at small sizes.

In *C. equiselis,* there is a greater difference in height, the anterior e always being highest.

The anal fin of *C. hippurus* is higher posteriorly and there seems be a greater difference than in its dorsal. In *C. equiselis,* the anteri end is again higher than the posterior.

Fork length. This measurement, the distance from snout to fork of ta is rather consistently about 10% greater than standard length.

LENGTH-WEIGHT RELATIONSHIP

The graph (Fig. 11) showing change of weight with length is bas not only on our own data, but on that accumulated by Mather, whi includes all the *C. equiselis* weights, and that in the literature (Ande son *et al.,* 1956, 1957; Bonham, 1946; Morrow, 1954; Schuck, 19

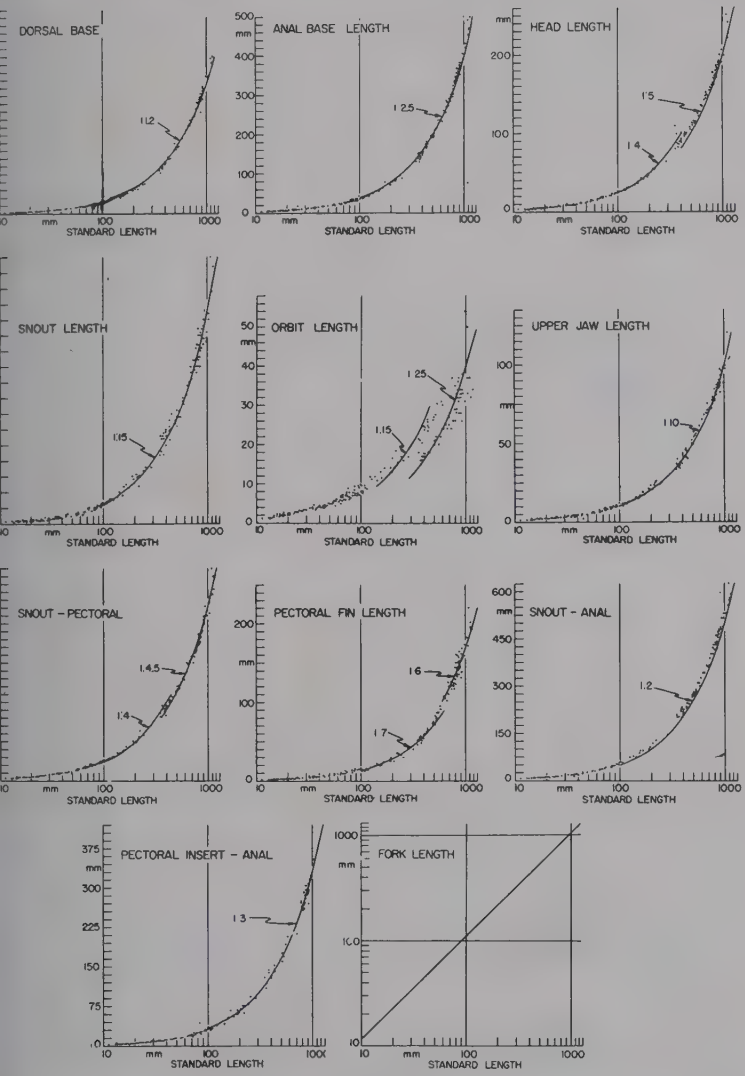


FIGURE 9. Semi-log. plots of body part — standard length relationships not showing differences in dolphin species. Species are not distinguished. Lines are hides, not necessarily regression lines.

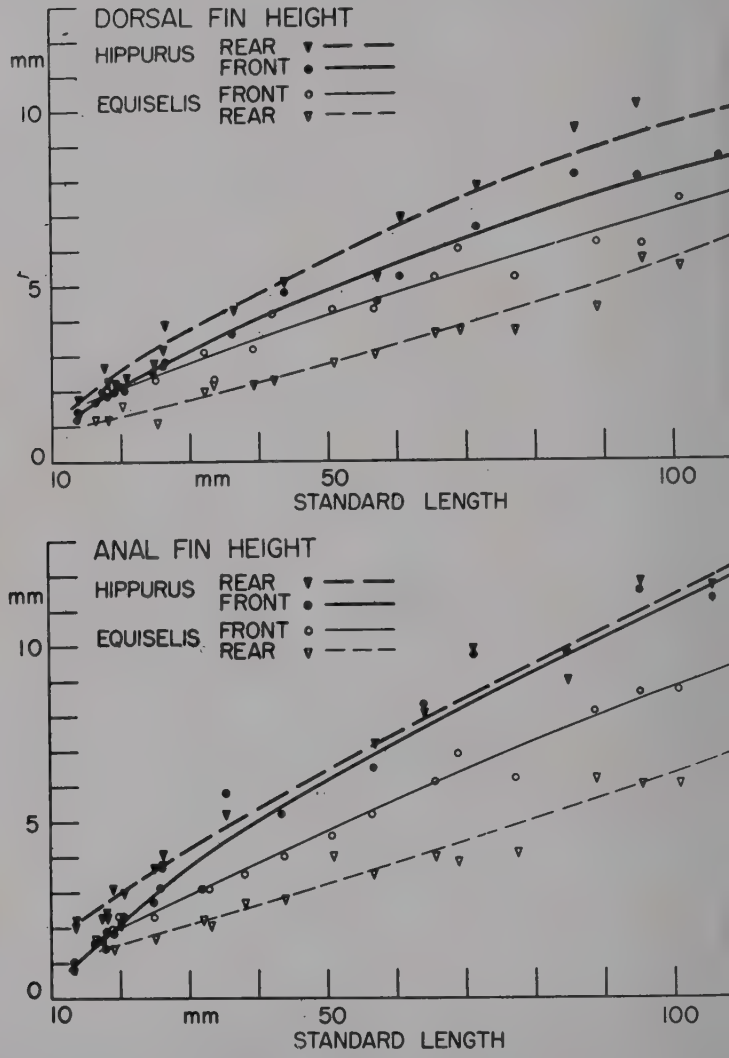
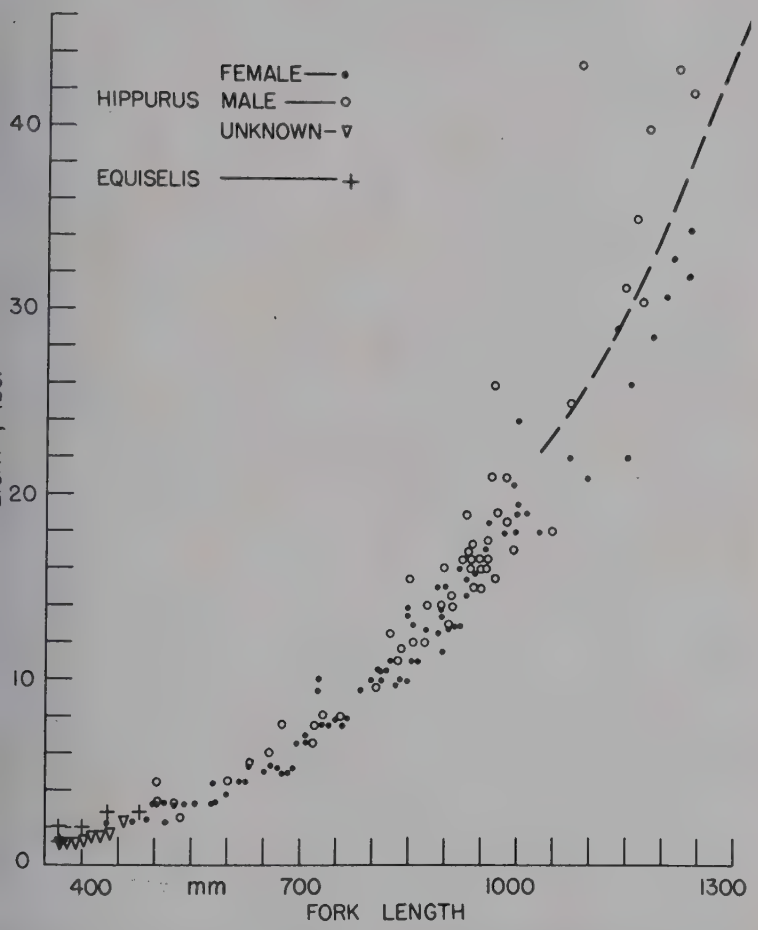


FIGURE 10. Relationship of front and rear heights of dorsal and anal fins in *Coryphaena*.



IGURE 11. Length-weight relationship in *Coryphaena* (principally *C. hippurus*). ashed line emphasizes the difference in weight of males and females over 000 fork length.

and b). Although Morrow was concerned with dolphins off the east oast of Africa and Bonham with those of Hawaii, their data are not ut of line with the western North Atlantic data.

In *C. hippurus* up to about 950 mm., there is no apparent sexual

difference in weight. Above that size, males appear to be heavier than females. That weight can vary considerably is shown by two large males, 1180 and 1175 mm, which weigh 40 and 30.5 lbs., respectively.

Geographic Distribution

Both species appear to be cosmopolitan in warm seas. In reviewing literature records, we found *C. hippurus* recorded very commonly, but since *C. equiselis* may not have been recognized, most of these records are somewhat doubtful.

If identifications are correct, *C. hippurus* is much more abundantly caught by various commercial and sport fisheries than is *C. equiselis*. The extreme published latitudinal records in the Atlantic that have come to our attention are those of Vladykov and McKenzie (1935), who record a specimen ca. 2 feet long in Bedford Basin, Halifax Harbour, Nova Scotia, on August 7, 1901, and of Barnard (1927), who records the species from Cape Seas, Table Bay, and False Bay, on the southern tip of Africa. In a letter to Howard A. Schuck, L. R. Day reports three specimens about 14 inches long salted at North Rustico, Prince Edward Island, in 1945. Roughly, then, the distribution may be said to be limited latitudinally by the 45° line, which corresponds to the poleward limits of the 15°C(59°F) isotherm, as shown in the Meteor Atlas (Böhnecke, 1936). In the northern hemisphere at least, dolphins are rare at the extreme limit, and their general range can probably best be described by the 20°C (68°F) isotherm in the same atlas. Only four records north of Cape Cod, other than those noted above, are known to us (MacCoy, 1931; Schuck, 1951a; Scattergood, 1953; Bigelow and Schroeder, 1953). Most of our own catches have been at temperatures greater than 70°F. In March and April 1957, of fifteen long-line stations occupied by the M/V DELAWARE, the surface temperature was 70°F or higher at only two. One of these (70.0°F) produced a dolphin. The only other dolphin of the trip was caught where the surface temperature was 69.2°F, the third highest of all the stations. We recorded the catch for seven stations in June 1957. At four stations from 72.5° to 79.0°, dolphins were caught; at three from 66.1° to 70.9°, they were not. Of 22 stations in September and October 1957, nine produced dolphins. Surface temperatures at these successful stations ranged from 72.0°F to 81.0°F. The others ranged from 69.5° to 81.5°. The negative results at lower temperatures during the spring and summer trips corroborate our postulated temperature limitation, while the fall results do not contradict it.

In accord with its general propensity for warm waters, *C. hippurus* is quite common at certain times in the Caribbean Sea (Erdman, 1956), in the Gulf of Mexico (Baughman, 1941; Springer and Bullis, 1956), in the Florida Current (Anderson *et al.*, 1956, 1957), and in the Gulf Stream (Schuck, 1951a). Where the Gulf Stream system comes close to land, sport fishermen on the Atlantic coast of the United States are able to catch them in considerable numbers. This is notably true of southern Florida, Cape Hatteras, Ocean City, Maryland, and intercalated areas.

The only reference to relative abundance correlated with depth of water is that of Schuck (1951a) who found, using average miles of surface trolling per fish hooked, the greatest concentrations in water 0-20 fm. and 100-1000 fm. Water 21-100 fm. and greater than 1000 fm. produced relatively few fish. This needs to be corroborated. For example, whereas Schuck caught no dolphins by trolling over more than 1000 fm. of water, the M/V DELAWARE, by longlining and hand lines, caught many over such depths, although no quantitation was attempted.

Coryphaena equiselis is so poorly known that little can be said of its distribution. In addition to a few mid-Pacific records (viz. Kendall and Radcliffe, 1912), Fowler (1928) reports one from between Easter Island and the Galapagos, Nichols (1909) describes one from the eastern Pacific, Snodgrass and Heller (1905) note a record by Jordan and McGregor (1899) from San Benedicto Island, and Deraniyagala (1952) records the species reliably from Gulifalu Island and the Maldive Islands in the Indian Ocean. Specimens have recently been noted by Clemens (1957) for the eastern Pacific.

In the Atlantic, relatively large specimens (over 300 mm) have been reported in various parts of the tropical Atlantic (Mather and Day, 1954; Mezelaar, 1919), and in the Gulf Stream off Cape Hatteras and southern New England (Gudger, 1932; Mather, 1954), and the Fish and Wildlife Service M/V OREGON has taken individuals in the Gulf of Mexico and the Caribbean (see Fig. 12). In the eastern Atlantic, the species is recorded without mention of size from the Azores (Hilgendorf, 1888), the Canaries (Steindachner, 1868), Madeira (Lowe, 1839), and Senegal (Cadenat, 1950).

Young and intermediate-sized specimens have been taken more commonly than larger ones (intermediate, Fig. 12, young, Fig. 13), and they will be discussed in the next section.

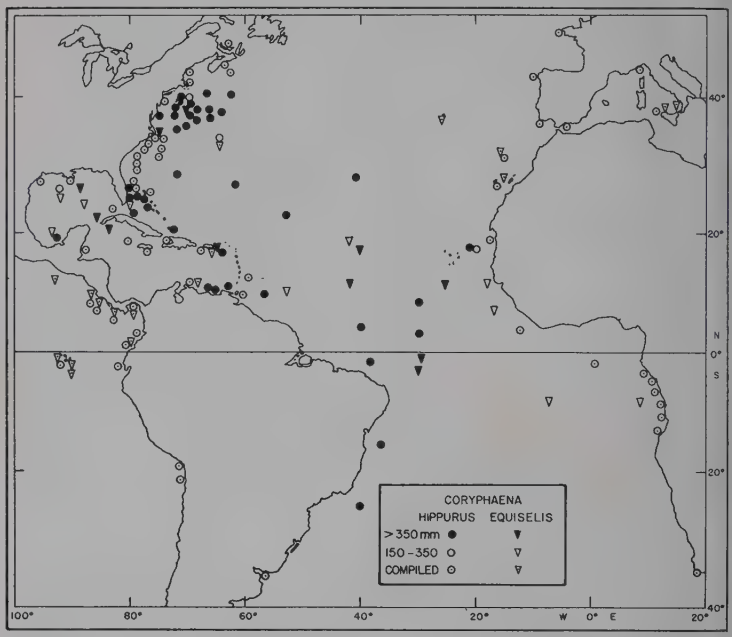


FIGURE 12. Distribution of intermediate-sized and adult dolphins in the Atlantic from specimens examined and from selected references (compiled).

SPAWNING AND SEASONAL DISTRIBUTION

Adults. The actual spawning act of dolphins has, presumably, not been observed. Certain distributional factors correlated with gonad condition give evidence of spawning time and place. Most data concern *C. hippurus.*

Erdman (1956) tabulated by months the distribution of 562 specimens of *C. hippurus* caught in Puerto Rican waters. He found them most abundant in January to March, almost absent in the summer, and moderately common again from October through December. In February, the month of greatest abundance, the ovaries had eggs in the most advanced stage of development. We have no information to explain their relative absence during the summer.

The records of Anderson *et al.* (1956, 1957) for the region of the Florida Current indicate that most of the dolphins caught by trolling

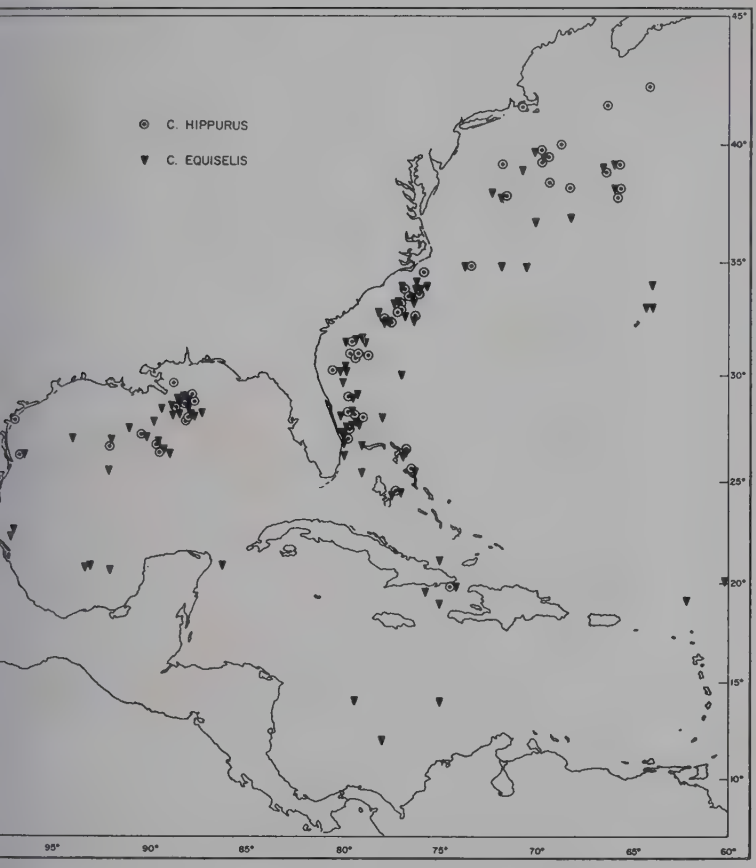


FIGURE 13. Distribution of young (less than 150 mm) dolphins in the western north Atlantic from specimens examined only.

n April and May were either very close to spawning condition or ripe, whereas those caught in July and August were not. The spawning eason, therefore, appears to be later here than in the Caribbean.

C. hippurus caught in the vicinity of the Gulf Stream *(sensu stricto)* n June were either ripe or very close to it, and the species was present n large numbers at this time. In March and April, only two dolphins vere taken either by long line or hand line. In June they were abun-

dant on long line and not uncommon on incidental hand lines. In September and October, the abundance on long line sets dropped off considerably, though quite a few were caught on hand lines. Fig. 14 indicates the relative seasonal abundance of adults in the Gulf Stream and compares this with Erdman's (1956) Puerto Rico data.

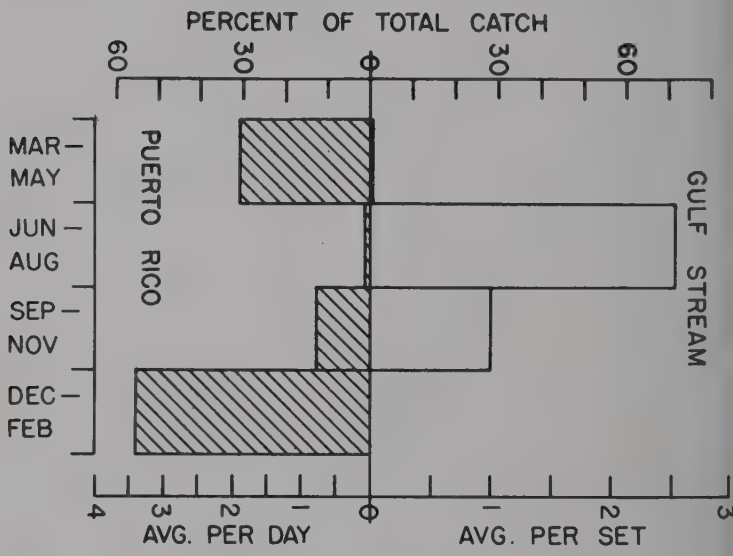


FIGURE 14. Relative seasonal abundance of adults of *C. hippurus* in the Gulf Stream (M/V DELAWARE data) and Puerto Rico (from Erdman, 1956). Gulf Stream data are given as average catch per long-line set. Puerto Rico data are given as average catch per day by sport fishermen. Both are reduced to percentage for comparison.

We have also noted ripe females caught off Ocean City, Maryland in July and August 1957.

In the Indian Ocean, off the coast of east Africa and in the Mauritius-Seychelles region, Williams (1953) found ripe females in March and suggested a possible shoreward spawning migration there from February to June.

It thus appears that *C. hippurus* may gather in certain broad areas to spawn as the surface temperature rises toward its midsummer maximum. Since a similar temperature is probably reached earlier in the

Caribbean than in the Florida Current or Gulf Stream, this may account for the discrepancy in spawning times between the two areas. Mather, however, reports (pers. comm.) finding ripe fish off the Virgin Islands at late as August, and de Sylva *(in litt.)* has seen them throughout the year at Miami.

Evidence of spawning time and place of *C. equiselis* comes from a specimen 205 mm standard length (ca. 9 inch), collected from the M/V CRAWFORD in March, 1957, which had well-developed eggs. This is far smaller than any *C. hippurus* observed in the same condition. Gerdman (1956) reported Puerto Rican specimens 12-14 inches in fork length with well-developed eggs in August and October 1956, and recently told us *(in litt.)* that on September 7, 1957, in the stomach of a blue marlin *(Makaira ampla)* he found three specimens 10-12 inches fork length with orange ovaries and well-formed eggs.

Young. The distribution of young dolphins in time in the various parts of the western Atlantic where dip-net collections have been made corroborates the evidence obtained from the adults and gives further information. However, there exists a seeming paradox. Whereas larger specimens of *C. hippurus* are relatively easy to obtain and those of *C. equiselis* are seldom seen, the young just reverse this picture. In the collections examined in this study, there was a total of 122 young of *C. hippurus* (53 from the Gulf Stream, 48 from the Florida Current, 21 from the Gulf of Mexico) as contrasted to 353 specimens of *C. equiselis* (44 from the Gulf Stream, 152 from the Florida Current, 157 from the Gulf of Mexico). Probably, *C. equiselis* is more a mid-ocean inhabitant than *C. hippurus* and prefers more tropical waters. Most of the few available adults of *C. equiselis* used in this study were, indeed, from equatorial or sub-equatorial Atlantic waters, the exceptions being those from the Gulf Stream. DeSylva has informed us that in southern Florida, *C. hippurus* adults are caught both in the Gulf Stream and at its junction with coastal water, and that they occasionally enter inshore waters of rather high turbidity. *C. equiselis,* however, seems to be strictly oceanic over deeper waters. We have seen small specimens of *C. hippurus* caught in shallow water near docks in Rockport, Texas (cf. Pew, 1957), Woods Hole, Mass., and Biscayne Bay, Fla. No such reports are available for *C. equiselis.* This upholds the contention that *C. hippurus* tolerates coastal waters and breeds farther inshore than *C. equiselis.*

In the Gulf of Mexico, from which specimens of *C. equiselis* are abundant, we have seen specimens taken from April through August

and in November and December. The distribution of sizes by seaso is shown in Fig. 15. In the five spring and summer months, most of th young are between 10 and 50 mm, with no prominent mode. It seems however, that larger specimens become more common in the late months. This suggests that *C. equiselis* breeds throughout spring an summer in that region. The size distribution in November and De cember lies principally between 40 and 70 mm, indicating an increas in size and probably also that the breeding season is generally past.

Comparatively few data are available for the young of *C. hippurus* but a picture for the Gulf similar to that of *C. equiselis* is suggested.

In the Gulf Stream, in spring and summer we have collected onl two young *C. equiselis*. In the fall, however, numerous young of thi species have been taken, very few of which have been in the very sma size classes; most were 40-70 mm, with quite a few larger. This suggest that *C. equiselis* does not breed within the immediate influence of th Gulf Stream, but that the fall influx comes from another breedin ground.

C. hippurus shows a different seasonal pattern. No young wer caught in the Gulf Stream in March and April. In June, many wer caught, all in the smaller size range. In September and October, agai quite a few were collected, and the size range shows a decided increase It would seem that the species breeds in or near the Gulf Stream, whic corroborates our earlier evidence, and that early summer is the mos intense breeding period.

The relatively few specimens from the Gulf of Mexico appear t indicate a longer breeding season there, possibly extending from Apr through July or August, as did that of *C. equiselis*. It is difficult t explain the scarcity of young of *C. hippurus* in the Gulf unless th adults are also somewhat scarce, which, as attested by Springer an Bullis (1956), is surely not the case.

Recently, we have been fortunate in being able to examine th young dolphins collected by the Fish and Wildlife Service in th Florida Current and Bahamas Region. The seasonal distribution o these specimens (Fig. 16) approaches the picture in the Gulf o Mexico far more closely than that of the Gulf Stream. There is n paucity of specimens of *C. equiselis* in spring and summer; rather ther is evidence of breeding at all seasons including winter. The obviou difference between the patterns of *C. equiselis* in the Gulf Stream an in the Florida Current is disconcerting, as it would seem logical t expect a more or less continuous phenomenon, whereby considerabl

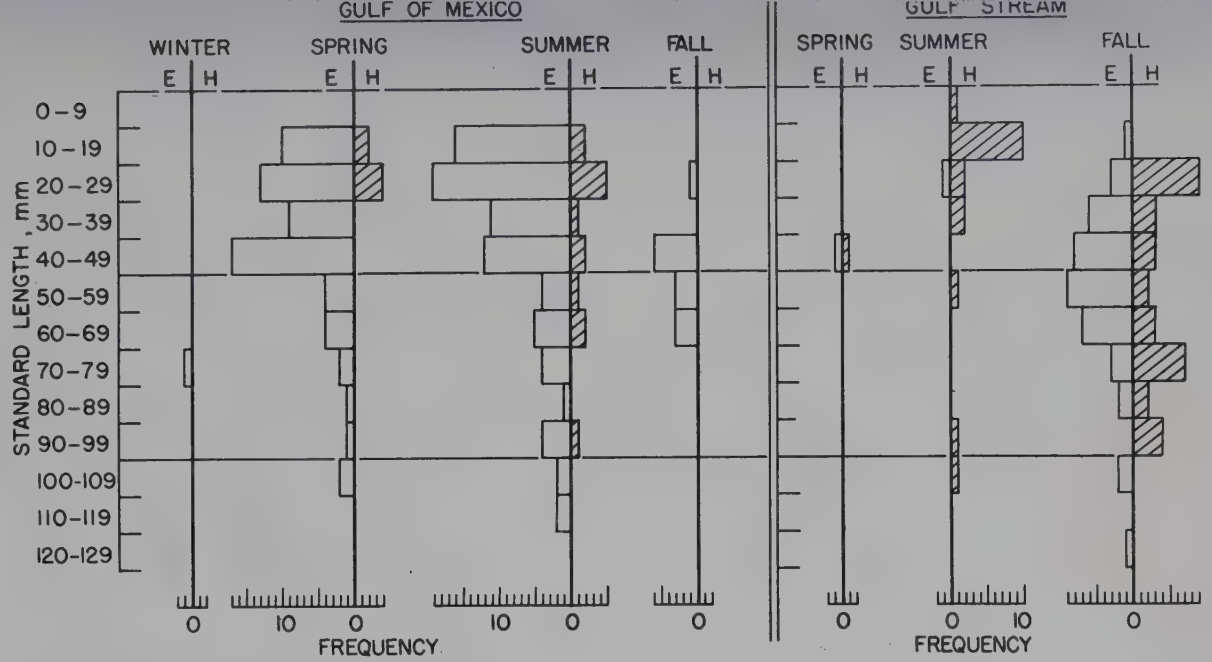


FIGURE 15. Relative seasonal abundance of young of *Coryphaena* in the Gulf of Mexico and the Gulf Stream. E, open bars = *C. equiselis;* H, crosshatched bars = *C. hippurus.*

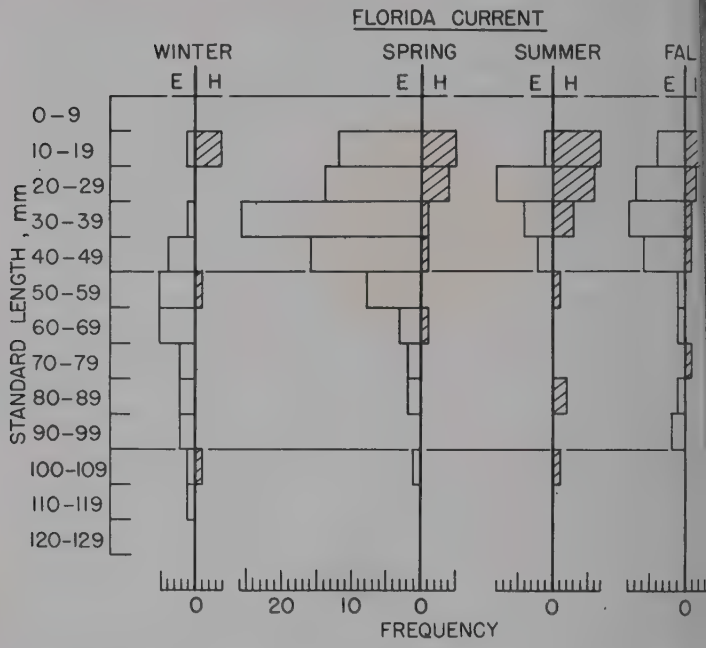


FIGURE 16. Relative seasonal abundance of *C. equiselis* (E, open bars) a *C. hippurus* (H, cross-hatched bars) in the Florida Current.

numbers of specimens would be carried into the Gulf Stream at tim when they are abundant in the Florida Current. We are unable adequately explain this disjunct situation.

SEX RATIO

In the Gulf Stream region sampled by the M/V DELAWARE, we fou essentially a 50:50 sex ratio, as shown in Table 2. Data from Math for the Virgin Islands, consisting largely of winter records, indicat a preponderance of females, about a 65:35 ratio. We are unable explain satisfactorily the difference between these areas. Assumi that specimens from the Virgin Islands were correctly sexed, the spri abundance in the Caribbean, indicated by Mather's data and that Erdman (1956), may be a pre-spawning migration, mainly of femal

TABLE 2

SEX RATIOS FOUND AT VARIOUS SEASONS IN THE GULF STREAM (FROM "DELAWARE") AND AT ST. CROIX, VIRGIN ISLANDS (FROM MATHER).

	Males	Females
Gulf Stream Oct. 1956	8	8
Gulf Stream June 1957	17	14
Gulf Stream Fall 1957	5	5
Gulf Stream Total	30	27
St. Croix Oct. 1956-May 1957	25	47

FEEDING HABITS OF *C. hippurus*

tomachs of 46 adults of *C. hippurus* from the Gulf Stream were lyzed to determine species composition and number of fish eaten. found a minimum of 32 species of fishes belonging to 19 families, least one species of crab *(Portunus sayi)*, one shrimp, and four halopods, as well as *Sargassum* weed, (Table 3). Empty stomachs e not been considered.

TABLE 3

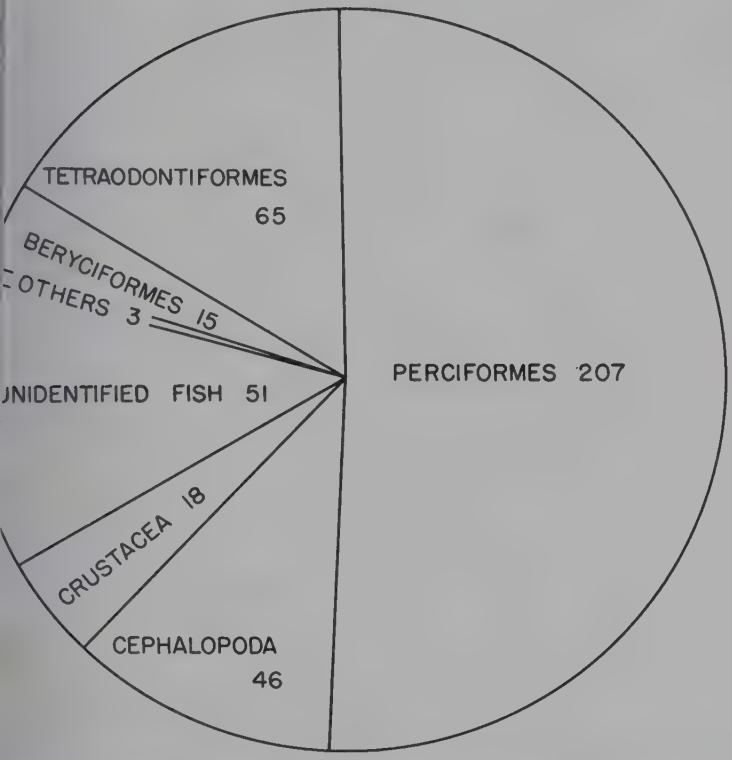
D ITEMS OF *Coryphaena hippurus* SHOWING NUMBER OF STOMACHS IN WHICH H WAS FOUND AND NUMBER OF INDIVIDUAL ITEMS FOUND IN ALL STOMACHS.

	Number of Stomachs	Number of Individuals
halopoda	28	46
Unidentified	23	33
Decapoda		
Illex illecebrosus	1	1
Species?	4	5
Octopoda		
Argonauta argo	4	6
Pterygioteuthis giardi	1	1
Tremoctopus violaceus	1	1
stacea	15	18
Crab		
Portunus sayi	7	10
Species?	6	6
Shrimp-Species?	2	2
hes	42	342
Scopeliformes-Myctophidae	1	1
Beloniformes		

TABLE 3—*Continued*

FOOD ITEMS OF *Coryphaena hippurus* SHOWING NUMBER OF STOMACHS IN WHI EACH WAS FOUND AND NUMBER OF INDIVIDUAL ITEMS FOUND IN ALL STOMACH

	Number of Stomachs	Number of Individua
Scomberesocidae-*Scomberesox saurus*	1	1
Syngnathiformes		
Syngnathidae-*Hippocampus hudsonius*	1	1
Beryciformes	4	15
Holocentridae		
Holocentrus ascensionis	1	4
H. bullisi	1	4
H. species?	4	7
Perciformes	16	207
Acanthuridae-*Acanthurus* species?	3	3
Ammodytidae-*Ammodytes americanus*	1	31
Bramidae-species?	1	1
Carangidae	7	15
Caranx crysos	2	2
C. latus	1	1
C. ruber	1	1
C. species?	1	1
Decapterus punctatus	2	4
Selar crumenophthalmus	1	5
unidentified	1	1
Coryphaenidae-*Coryphaena hippurus*	2	2
Gempylidae	3	106
Gempylus serpens	1	1
Nealotus tripes	2	105
Trichiuridae-*Diplospinus multistriatus*	1	2
Scombridae	6	39
Auxis thazard	5	38
Euthynnus alleteratus	1	1
Xiphiidae-*Xiphias gladias*	4	8
Tetraodontiformes	17	65
Balistidae	14	20
Balistes capriscus	1	1
Canthidermis maculatus	2	3
C. sobaco	4	5
Xanthichthys ringens	6	8
unidentified	3	3
Diodontidae-*Diodon hystrix*	3	4
Molidae-species?	1	1
Monacanthidae	8	13
Monacanthus hispidus	7	11
M. tuckeri	1	2
Ostraciidae-*Lactophrys triqueter*	1	1
Tetraodontidae	4	26
Sphaeroides spengleri	1	4
S. species?	3	22
Unidentified fishes	29	51



URE 17. Numerical abundance of organisms in stomachs of *C. hippurus* by major categories. Figures represent actual total numbers.

We find fishes the most abundant item, occurring in 42 out of 46 machs. Three of the other four contained cephalopods only, the er one both cephalopods and crustacea. The numerical contribution the various types of animals is shown in Fig. 17. Because numbers specimens were not recorded for some stomachs examined at sea, h such case was counted as one individual. We thus have a mini- m number of individual items. The order Perciformes contributed re than half the total. A little over half of this number was a single cies *(Nealotus tripes)* found in stomachs of two fish captured on the ne day. One stomach had 29, another 16 specimens of *Auxis,* and single dolphin examined from Ocean City, Maryland, contained 31

Ammodytes. These represent the only instances where more than te individuals of a fish species were recorded from a single stomac Because of these few instances, the evaluation is perhaps biased towa Perciformes; however, the unidentified category probably consis largely of this order.

Considering the number of stomachs in which each category represented, the order is changed (Fig. 18), the two leading fish orde reversing their positions. The Carangidae (7 stomachs) Balistid

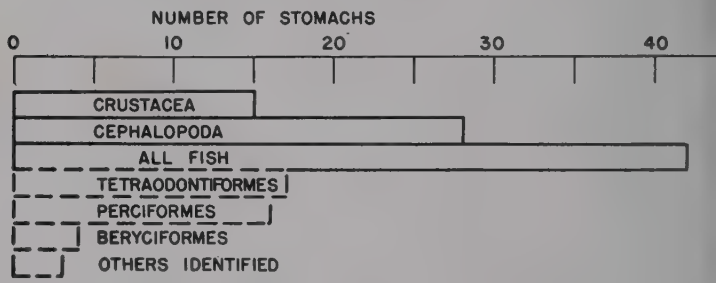


FIGURE 18. Frequency of occurrence of fishes and invertebrates in stomachs *C. hippurus*. Upper (solid bars): major groups. Lower (dashed bars): orde of identified fishes.

(14) and Monacanthidae (8), which are the three most-freque families, are the forms most commonly associated with *Sargassum*, shown by dip-net collections. At least eight stomachs contained *Sa gassum*. It appears, therefore, that the dolphins are feeding to considerable extent on this readily available source of food. There no apparent selectivity. This point is further borne out by the sing fish from Ocean City which contained only *Ammodytes*, a ve abundant shallow-water fish.

Flying fishes were never identified among the stomach conten although they were not uncommon in dip-net collections made at night light. These are reputed to be the favorite food of dolphins, b our evidence points to the contrary, at least in the Gulf Stream. further corroborates our contention that selectivity is not a maj factor in the feeding habits of dolphins, as presumably flying fish although available, are more difficult to catch than the relative sedentary forms inhabiting the *Sargassum*. DeSylva *(in litt.)* has not that dolphins caught off Miami, Florida, also feed heavily on the *Sa gassum*-fauna, but that flying fishes are common in the diet there.

Our findings compare favorably with those of Ronquillo (1954), who studied Philippine dolphins, in which Trichiuridae (closely related to Gempylidae) were most abundant numerically, followed by Tetraodontiformes, *Auxis,* Syngnathiformes, Holocentridae, and Carangidae.

Empty stomachs were found in none of 30 dolphins examined in June 1957; only one of ten in Fall 1957 was empty. These fish were all caught during the morning hours, mostly by long line. Nine of 15 dolphins caught on hand lines at night in October 1956 had empty stomachs. Possibly the species does not feed well in darkness.

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CAPITELLIDAE AND NEREIDAE (MARINE NNELIDS) FROM THE GULF SIDE OF FLORIDA, ITH A REVIEW OF FRESHWATER NEREIDAE

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ABSTRACT

Capitomastus aciculatus, new species, *Capitellides jonesi,* new species, and *Capitella capitata floridana,* new subspecies, are described. NAMANEREINAE, new subfamily, is proposed for a group of freshwater nereids, previously called LYNCASTINAE, and *Namalycastis,* new genus, is proposed for one group of these nereids.

Family CAPITELLIDAE

This family is previously reported from the Gulf of Mexico for ven species in six genera (Hartman, 1951, p. 101). The four new cords and species described below originate from St. Andrews Bay, orida; all were collected by Dr. Meredith Jones, Oceanographic Initute, Florida State University, to whom I am indebted for the receipt the collections. The types of new species are deposited in the Allan ancock Foundation of the University of Southern California.

Genus *Capitomastus* Eisig, 1887

This genus is characterized in having 9 thoracic and a variable umber of abdominal segments. The first visible segment is setigerous. enital spines on the dorsal side of the ninth, or also eighth segment, e present in both male and female individuals. This differs from *apitella* (see below) in which the female has normal hooded hooks the last two thoracic notopodia. It differs from *Capitellides* (see elow) in which the first visible segment lacks parapodia. *Type ecies*: *C. minimus* (Langerhans, 1881).

Capitomastus aciculatus, new species

Plate 1, Figs. 1-3

Length of a mature individual is 35 mm; width in the middle or idest part of the thorax is 1.8 mm. The body consists of a short rostomium, 9 thoracic, and about 90 abdominal segments. The thorax short barrel-shaped and about two fifths as wide as long (Fig. 1). he much longer abdominal region is slender and terete. There are no ranchiae or long parapodial processes. The last 10 segments taper pidly and end in a constricted, inconspicuous pygidial ring.

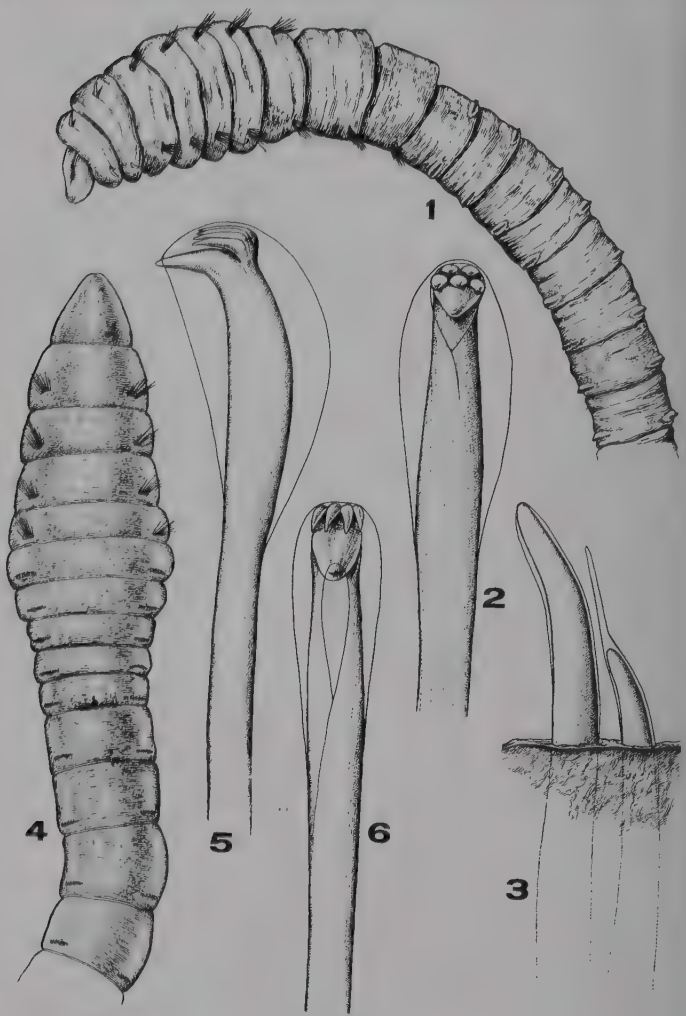

PLATE I

Capitomastus aciculatus, n.sp. (St. Andrews Bay): 1. Anterior end with thora and first 8 abdominal segments, seen from the left side, showing relations o spines, setae and hooks (the genital spines in 8th and 9th segments are no

The prostomium is broadly triangular and has a deep median de ession on its dorsal side; it lacks visible eyes. The first and second gments are unique for having blunt acicular spines (Fig. 1); they mber 2 or 3 in a fascicle, and occur in notopodia of both males and males, but only in neuropodia of males; in the female they are re aced by normal slender, distally pointed setae. In the male the next notopodia have setae and the last 2 thoracic notopodia have genital oks; the next 6 neuropodia have setae and the last one has setae and oded hooks. In the female the first 2 notopodia have acicula, the xt 5 setae, followed by one with setae and hooks, and one with nital spines; neuropodia include 8 with setae and 1 with hooded oks. These formulas may be expressed where a = acicular spine, = seta, g = genital spine and h = hooded hooks, as follows: in the ale notopodia: 2a + 5s + 2g; male neuropodia: 2a + 6s + 1s 1h; in the male notopodia: 2a + 5s + s/h + 1g; female neuropodia: 8s + 1h.

Parapodial ridges of both thoracic and abdominal regions are widely parated from one another so that the space separating a pair of otopodia is about the same as that between dorsal and ventral rami. bdominal tori are slightly elevated ridges located nearer the posterior d of the segment; they have single series of few uncini numbering 5 14 in a row.

Under high magnification the heavy acicular spines of the first two gments are seen to be slightly curved, and, when unworn, have a licate hyaline hood with a long, slender cap (Fig. 2). Worn spines ten lack the distal hood. Genital spines are yellow, acicular and lack hood. Abdominal hooded hooks have a long shaft and terminate stally in a recurved fang surmounted by 5 smaller teeth in 2 rows ig. 3); the hood is close-fitting. Ova removed from the body cavity easure about 0.025 mm in diameter.

Capitomastus aciculatus differs from the only other known species the genus *C. minimus* (Langerhans) from Europe, for having acicu r spines in the first two segments.

sible), x 12. 2. Abdominal hooded hook, seen from the front, showing the rge fang and 5 teeth in 2 rows, x 700. 3. Acicular spines from the first noto- odium, showing one with worn, the other with unworn hood, x 243.

apitella capitata floridana, n. subsp. (St. Andrews Bay): 4. Anterior end with orax and 4 abdominal segments in dorsal view, x 46. 5. Abdominal hooded ook seen from the side, showing fang and 4 teeth, x 2820. 6. Abdominal ooded hook seen from the front, with fang, row of 4 teeth and hood, x 2820.

Locality. St. Andrews Bay, Florida, taken in the Old Channel, Oc tober 11, 1957.

Genus *Capitellides* Mesnil, 1897

Species of this genus are characterized in having a prostomium wit a pair of eyes followed by a thorax of 10 segments. The first segmen is an incomplete smooth ring, and the last 9 segments have biramou parapodia provided with setae or hooks. Individuals of both sexe have genital spines in the last two thoracic notopodia. *Capitellide* approaches *Capitella* (see below) from which it differs in having th first segment a smooth ring and both male and female individuals hav genital spines. The genus is known for 2 species, *C. giardi* Mesnil from France, and the questionable *C. teres* Treadwell, from Por Aransas, Texas (see below). *Type species*: *C. giardi* Mesnil, 1897.

Capitellides jonesi, new species

Plate 2, Figs. 1-3

Length of mature individuals is 12 to 15 mm; width in the thorax i 1.0 mm. The body consists of 10 thoracic and about 28 abdomina segments, with the last few very short; the body terminates in a con stricted pygidial ring. There are no branchial or prolonged parapodia processes. The thoracic region is short inflated and slightly depresse (Fig. 1). Abdominal segments are long and cyndrical, with the firs several about as long as wide, then gradually becoming longer so tha the length is several times the width. Far back the segments are agai very short. Abdominal tori are located near the posterior end of th segment and in front of the segmental groove.

The prostomium is an equitriangular, depressed lobe with a pair o small eyespots at the sides (Fig. 1). The peristomium is visible onl dorsally, as a smooth ring; laterally it diminishes gradually, and ven trally it is absent. The second visible segment is the first setigerous one

Thoracic segments have the same setal formula in both male an female individuals. The first 3 segments have long, distally pointe setae in both notopodia and neuropodia. The next 4 notopodia hav long-handled, hooded hooks (Fig. 2) and the last 2 have genital spine numbering 3 or 4 in a fascicle. The last 6 thoracic neuropodia hav only hooded hooks which resemble those in notopodia. The formula can be expressed: notopodia: 3s+4h+2g; neuropodia 3s+6h. Ab dominal parapodial ridges are wide apart, so the 2 of a pair are abou as far distant as the dorsal or ventral pairs are from each other. The

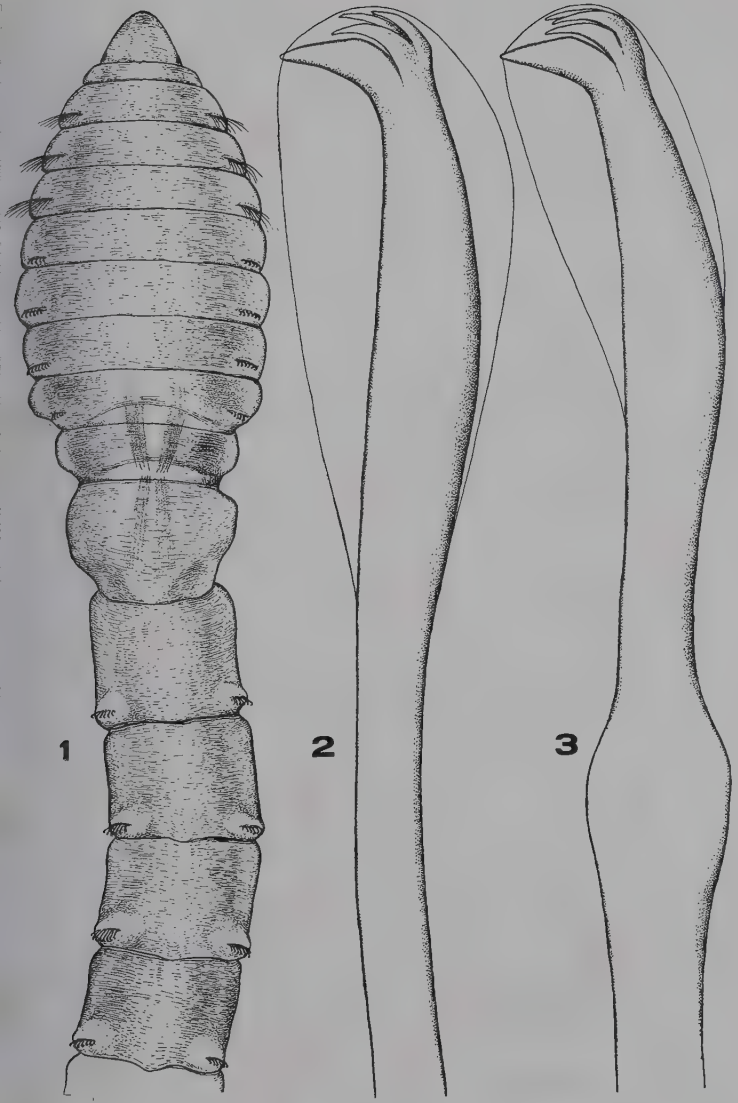

PLATE II

Capitellides jonesi, n.sp. (St. Andrews Bay) 1. Anterior end in dorsal view, with thorax and first 4 abdominal segments, x 42. 2. Thoracic hooded hook seen from the side, x 1394. 3. Abdominal hooded hook with shoulder, seen from the side, x 1394.

are provided with long shafted, hooded hooks which resemble those o the thorax but have a conspicuous shoulder (Fig. 3); the distal en terminates in a large fang surmounted by 3 teeth, with two below an one above (Fig. 3). Some individuals are sheathed in a translucen mucoid tube, externally lightly covered with lenticular-shaped pellets

C. jonesi differs from the type species, *C. giardi,* most conspicuousl in its thoracic setal formula. In *C. jonesi* the first 3 segments hav pointed setae and the next 4 have hooded hooks, whereas in *C. giard* the first 6 segments have setae, followed by one with hooded hooks In *C. jonesi* the genital armature consists of about 12 to 16 spines whereas in *C. giardi* there are only about 4 spines.

It is a pleasure to name this species for its collector, Dr. Meredit Jones, whose intelligent pursuit for the interesting, and patient atten tion to important details, have resulted in unusual finds here described

Locality. Capitellides jonesi was taken in St. Andrews Bay, Florida in the same locality as *Capitomastus aciculatus* (see above). The tw are at once distinguishable in gross size, with the first much smaller

?Capitellides teres Treadwell, 1939

?Capitellides teres Treadwell is reported from Texas by Hartma (1951, p. 101). This differs from typical species of the genus in hav ing 8 anterior segments provided with pointed setae; segments 9 an 10 have long handled hooks, and an ovigerous individual has larg yellow genital spines in a posterior thoracic segment. It remains know only from Port Aransas, Texas.

Genus *Capitella* Blainville, 1828

Capitella is characterized in having 9 thoracic setigerous, and larger and variable number of abdominal segments. The first visibl segment has setae. Males have large genital spines and females hav long handled hooded hooks in the last two thoracic notopodia. Th type species, *C. capitata* (Fabricius), is the most widely reported o the family; it has been recorded from Arctic to Antarctic seas an from cold to warm water areas. It is best known through description based on European collections (see Fauvel, 1927, 16:154). Specimen from the Gulf of Mexico depart in some details from those describe from Europe. *Type species*: *C. capitata* (Fabricius, 1780).

Capitella capitata (Fabricius, 1780)

Capitella capitata (Fabricius, 1780); Fauvel, 1927, p. 154; Hartman, 195 p. 101

A single female individual, collected from St. Andrews Bay, Florida

rees fully with another one from Aransas Bay, Texas (see Hartman, 51, p. 101). The prostomium is followed by 9 thoracic setigers; in topodia there are 7 segments with setae and 2 with hooks; in neuro- dia there are 6 segments with setae and 3 with hooks. The female :ks genital spines. Typical specimens from Europe are characterized having 6 segments with setae, 3 with setae and hooks, and in the ıle the last two notopodia have genital spines.

Capitella capitata floridana, new subspecies
Plate 3, Figs. 4-6.

Many very small capitellids were found in egg capsules of squid, gely concentrated in the semi-opaque capsular matrix near its place attachment. Larger ovigerous individuals are only 6.2 mm long and ıles are about two thirds as large. Width in the middle thorax is 0.56 n. Segments number 40 or fewer. The body is depressed and broadest the middle thoracic region.

The prostomium is equitriangular and broadly exposed (Fig. 4); it :ks visible eyes. The first 4 segments have slender, distally pointed tae in notopodia and neuropodia. In the female, the next 5 segments ve hooded hooks in notopodia and neuropodia. In the male the ooks of the last two notopodia are replaced by genital spines; these ımber 2 in a fascicle and are pale yellow in color. The setal formula male thoracic segments can be expressed: notopodia: 4s+3h+2g; neuropodia: 4s+5h. In female the formula is the same for notopodia d neuropodia: 4s+5h.

The hooded hooks of abdominal segments have a large recurved ng surmounted by 4 teeth in a single row (Fig. 5-6). Seen from the le these 4 teeth can usually be partly seen since they appear to form oblique series; since the seta is thick shafted, the teeth are usually en in partial three-quarters view.

The collection contains mucoid tubes irregularly penetrating the uid matrix; some tubes are partly lined by single layered sheaths of a which individually measure 0.8 mm in diameter.

C. capitata floridana differs from the stem species in the formula of thoracic setae (see above); the hooded hooks have 4, instead of 3 eth in transverse series. A nearly related form, *C. capitata ovincola* artman (1947, p. 405, as *C. ovincola)* comes from southern Cali- rnia, also in squid egg clusters. It attains a much larger size, measures 60 mm long, and has a slightly different setal formula: male noto-

podia with 5s+2 s/h+2g; male neuropodia with 5s+2 s/h+2h; f male notopodia and neuropodia with 5s+2 s/h+2h.

It is of interest that another capitellid, *Capitomastus minimi* (Langerhans), has been recorded from squid egg capsules (Harar and Jecklin, 1933) from France. These authors concluded that th capitellid may secrete an enzyme which dissolves the capsular mem branes of the squid and makes them suitable for food of the capitelli *Locality. C. capitata floridana* was collected from squid egg cases i the vicinity of St. Andrews Bay, Florida.

Family Nereidae

The discovery of nereids with uniramous parapodia from the Gu side of northern Florida is of considerable interest, since it relate them to a small group of species, most of which come from freshwate habitats of cosmopolitan character. Species of two genera are her recorded from the Gulf of Mexico, and the subfamily to which the belong is emended.

Subfamily Namanereinae, new name

Includes Lycastinae Correa, 1948, p. 245.

Most nereid genera and species are readily distinguished from on another by characters concerned with pharyngeal structures and var ious parapodial parts. In the Namanereinae, however, such part are either lacking or much reduced. The proboscis has distal jaws bu lacks paragnaths or papillae. Parapodia are nearly uniramous, an the few setae present are not highly diagnostic unless studied in con siderable detail. Parapodia appear uniramous but are subbiramous the notopodium is represented by a dorsal lobe, an embedded notoaci culum, or also one or a few slender notosetae. Neuropodia are wel developed, have embedded acicula and setae usually of two or mor kinds. The prostomium has a pair of frontal antennae and usually 4 eyes in quadrate to nearly transversely linear series. The first visibl segment lacks parapodia; it has 3 or 4 pairs of peristomial cirri. Th next segment is the first parapodial one.

Most species inhabit fresh to brackish water, especially in area having had recent, or continue to have access to the sea.

Two to four generic groups may be recognized. In one group th named species have 3 pairs of peristomial cirri, with the second ventra pair lacking. Dorsal parapodial lobes are small and inconspicuou throughout the length of the body. Notopodial setae are represente

one or a few slender spinigers. Ova are few in number and giant in , and mature individuals are hermaphroditic. Adult size is small ninute, or about 10 to 40 mm long. This group retains the generic ne, *Namanereis* Chamberlin, for reasons given below.

n a second group of species there are 4 pairs of peristomial cirri. rsal parapodial lobes increase in size posteriorly. Notopodial setae almost or altogether absent. Ova are small in size and very num- us, and individuals are presumably dioecious. Adult size is larger l attains a length of 40 to 80 mm. This group has no valid generic ne. *Namalycastis,* new name, is here proposed and the species be- ging to it are listed below.

Another group with a single known species, *Lycastoides alticola* nson (1903), comes from a high mountain lake in Lower Cali- nia, Mexico. It has a deeply cleft prostomium with the anterior ks prolonged to form the antennae, and it lacks eyes.

A fourth species, *Lycastis geayi* Gravier (1901, p. 399) from nch Guiana, is said to lack falcigerous setae and the maxillae have teeth. Its generic status is doubtful since the number of peristomial tacles is unknown. All other described species can be placed in the t or second of these groups.

Recent finds of NAMANEREINAE from scattered intertidal and/or ckish habitats along the shores of the United States indicate that resentatives of the first groups may be widely distributed in tem- ate and tropical zones. Because of their small size and distribution the high spray zones or in estuaries, individuals are seldom found collectors.

Generic and specific categories have remained controversial, partly cause early descriptions have failed to distinguish important char- teristics, especially the number of peristomial cirri and the details dorsal parapodial lobes. The most commonly used names for fresh- ter nereids, - *Lycastis,* LYCASTINAE and lycastids, have no generic tus.

Briefly summarized, it has been shown that *Lycastis* Savigny, 1822 s erected for 2 species, *Nereis versicolor* Müller, a true NEREINAE, d *Nereis armillaris* Müller, a SYLLIDAE of the genus *Typosyllis. castis* is thus a synonym of *Nereis* Linnaeus, 1758. The next use, *castis brevicornis* and *L. brevipalpe* Audouin and Edwards, 1833, a small nereid from France, referred to one having uniramous para- dia and 4 pairs of peristomial cirri (Grube, 1850, p. 300, and ube, 1871, p. 47). This specific name has only historical interest

since it is based only on an original find (Fauvel, 1923, p. 331). Th next known species, *Namanereis quadraticeps* (Gay, 1849, as *L castis*) from Chile, was first very briefly described and reported fro more extensive areas by others (see below).

The presence of 3, or 4 pairs of peristomial cirri, which at on separates these nereids into 2 groups, is very incompletely known. seems to have been assumed by earlier authors (before 1922) th the typical number is 4 pairs, and that a fourth pair, when lackin was the result of accidental loss. Such is obviously the case for th most widely recorded, *Namanereis quadraticeps*. Johnson (1908 showed 2 pairs in an illustration and most authors failed to mentio the exact number of tentacles.

Other features of generic importance describe for this small for a length of 10 to 30 mm, segments number about 45 to 100, peris tomial cirri are very short, and maxillae have 4 to 7 teeth. Dors and ventral cirri are very short and do not increase in size going back Embedded acicula are dark to black, and neuropodia have spinige in superior, and short-appendaged falcigers in inferior position. In dividuals are hermaphroditic.

The number of specific names attributed to this group is considerabl but specific distinctions are meager or insufficient. The following lis the generic and specific names believed referrable, either to *Namar ereis* Chamberlin, 1919, or to *N. quadraticeps* (Gay, 1849), togethe with original localities.

Lycastis quadraticeps Gay, 1849, p. 25, from Chile.

Quatrefages, 1865, p. 500. Transcript only.

Ehlers, 1897, p. 70, and 1901, p. 121, from southern South Am erica.

Johnson, 1903, p. 214, and 1908, p. 371, from southern Sout America.

Benham, 1909, p. 242, from New Zealand.

Augener, 1918, p. 214, from southwest Africa.

Hartman, 1954, p. 27, from New Zealand.

Lycastis littoralis Müller *in* Grube, 1871, p. 47, from Brazil.

Namanereis quadraticeps Chamberlin, 1919, p. 194. New generi name.

Lycastopsis beumeri Augener, 1922, p. 42, and 1936, p. 346, fro the West Indies.

astoides pontica Jakubova, 1930, p. 869, from the Black Sea.

astella quadraticeps Feuerborn, 1932, p. 638. New generic name.

astopsis catarractarum Feuerborn, 1932, p. 651, from Sumatra.

astopsis amboinensis Pflugfelder, 1933, p. 69, from Amboina.

astopsis hummelincki Augener, 1933, p. 362, from the West Indies.

astopsis augeneri Okuda, 1937, p. 308, from Japan.

astopsis tecolutlensis Rioja, 1946, p. 211, from Vera Cruz, eastern Mexico.

astopsis pontica neapolitana La Greca, 1950, p. 2, from the Mediterranean Sea.

v localities. - Norfolk, Virginia (collected by Dr. F. Ferguson); vport and Tomales bays, California (collected by Dr. Robert Menzies).

tribution. - Cosmopolitan areas including eastern and western sides he United States and in the Gulf of Mexico; in high spray zones of rtidal or brackish areas.

castopsis hummelincki Augener, 1933, p. 362, from the West Indies, has recently been redescribed by Wesenberg-Lund (1958); t differs from others for lacking eyes and the pharyngeal jaws are unique. Its specific name is here emended to *Namanereis hummelincki* (Augener).

Genus *Namalycastis,* new name

neric diagnosis. - The prostomium is quadrate and provided with yes in trapezoidal to nearly transversely linear series. The perisium has 4 pairs of tentacles. Dorsal parapodial lobes increase in e posteriorly. Ova are small in size and very numerous, and inididuals are presumably dioecious. Length is about 40 to 90 mm.

pe species: Paranereis abiuma Müller *in* Grube, 1871.

The list of specific names, below, are believed to refer either to a gle species resembling the type, or to closely related, and generically ntical forms. Original names and place of origin are given.

ranereis abiuma Müller *in* Grube, 1871, p. 47, from Brazil.

castis ouanaryensis Gravier, 1901, p. 397, from French Guiana, Surinam, and Haiti.

castis senegalensis St. Joseph, 1901, p. 218, and Augener, 1918, p. 217, from Senegal.

Lycastis hawaiiensis Johnson, 1903, p. 210, from a spring in Honolu Hawaii.

Lycastis meraukensis Horst, 1918, p. 246, from New Guinea.

Lycastis indica Southern, 1921, p. 578, from India in brackish wat

Lycastis ranauensis Feuerborn, 1931, p. 639, from Sumatra and su cessfully transplanted to southern Europe.

Lycastis terrestris Pflugfelder, 1933, p. 66, from Sumatra.

Lycastis nipae Pflugfelder, 1933, p. 69, from Sumatra.

Lycastis vivax Pflugfelder, 1933, p. 69, from Sumatra.

Lycastis longicirris Takahasi, 1933, p. 41, from the Tamsui River northern Formosa.

Lycastis siolii Correa, 1948, p. 245, from the mouth of the Amaz River.

Namalycastis abiuma (Müller *in* Grube) 1871

Plate 3, Figs. 1-4

Length of a mature individual is 63 mm, width at the tenth segme is 2.1 mm without and 3.14 mm with parapodia; the body consists about 120 segments. The prostomium is approximately trapezoid and its anterior margin incised (Fig. 1). A deep median longitudin groove extends through most of its length. The 4 eyes are dark ar wide apart, with the 2 of a side nearly coalescent. Frontal antenn are short and conical. The palpi are broad and extend forward front of the prostomium; in dorsal view the spherical palpostyles a seen.

The 4 pairs of peristomial tentacles are short and blunt, with th longest hardly surpassing the length of the prostomium. The first se ment is smaller than the others, and the next one is the first setigerou Notopodial setae are absent, or an occasional slender composite spin ger accompanies a single dark embedded aciculum. Dorsal lobes a smallest in anterior segments and increase in size gradually to b largest (Fig. 2) in postmedian and posterior segments. At best the extend distally beyond the acicular lobe to the ends of the longest seta The ventral cirrus is short throughout the body.

The proboscis, seen by dissection, is smooth and lacks pharynge processes. The jaws are dark brown and have 10 teeth on the cuttin edge (Fig. 3); the subdistal tooth is broadly separated from the dist one.

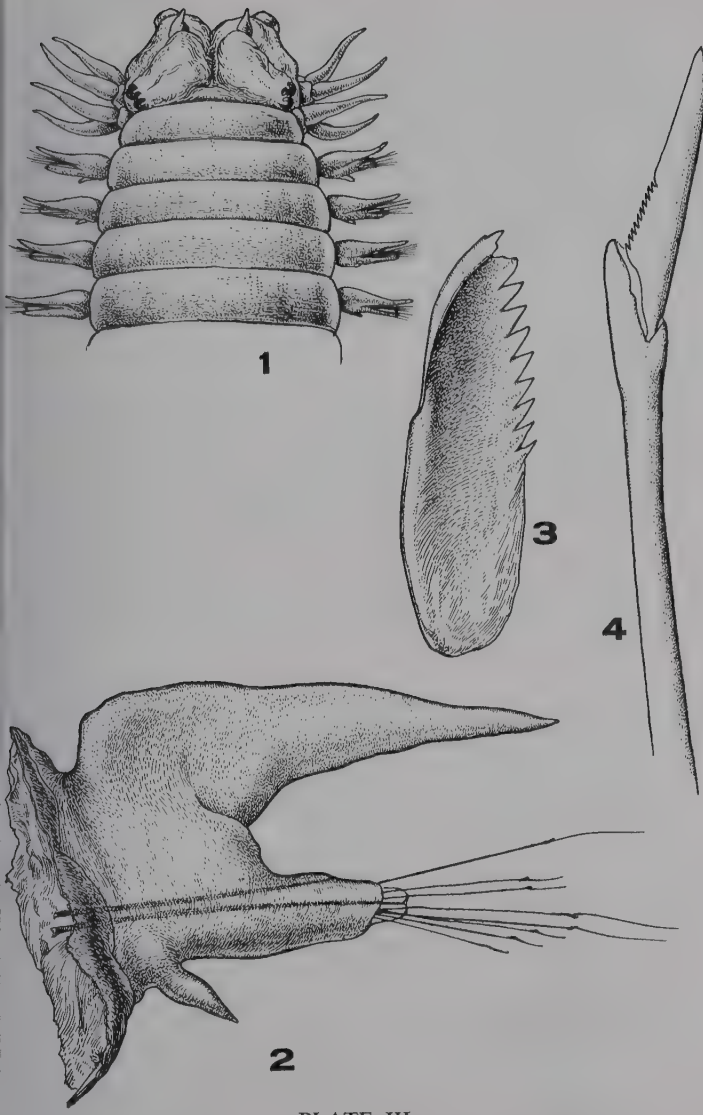

PLATE III

malycastis abiuma (St. Andrews Bay) 1. Anterior end including first four igerous segments, in dorsal view, x 25. 2. A median parapodium showing bedded acicula and setae, x 25. 3. Maxilla dissected out of proboscis, seen m the inner or concave side, x 43. 4. Inferior neuropodial falciger, in lateral w, x 266.

Setae consists of spinigers and heterogomph falcigers in about equ numbers. The appendage of the falciger is longer than broad and i cutting edge is nearly smooth (Fig. 4).

Distribution. - *Namalycastis abiuma* may have a circummundane di tribution in tropical and subtropical, brackish or estuarine localitie More specific localities are listed above.

Locality. St. Andrews Bay, Florida.

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A NEW SPECIES OF PARASITIC COPEPOD OF THE FAMILY LERNAEIDAE, *LERNAEENICUS MULTILOBATUS*, FROM A DEEP-SEA ANGLER-FISH[1]

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ABSTRACT

A new parasitic copepod of the family Lernaeidae, *Lernaeenicus multilobatus*, from the side of a deep-sea angler-fish *(Gigantactis* sp.), is described and figured. It agrees with *L. quadrilobatus* Yamaguti and Utinomi, 1953, in having bilaterally similar, soft, bulbous attachment processes, nearly all other members of the genus being equipped with bilaterally asymmetrical processes or hard, chitinous, horn-like ones. The number of rami on the thoracic legs differs from the genus description, as does the formation of the third thoracic leg which does not attach directly to the body but to a segmented ring which encircles the third thoracic segment and is attached to it on the dorsal surface. Additional material may require the erection of a new genus for those forms with a 1,2,1,2 thoracic leg ramal count and with the peculiar third thoracic leg formation found in *L. multilobatus*.

INTRODUCTION

The copepod described below was taken from the left side of a deep-sea angler-fish *(Gigantactis* sp.) caught in a commercial trawl at a depth of 210 fathoms east of New Smyrna, Florida. The possession of bilaterally similar, soft, bulbous attachment processes, a character shared in the genus *Lernaeenicus* with *L. quadrilobatus* Yamaguti and Utinomi, 1953, the processes of which are specifically different from the present specimen, in addition to different thoracic leg characters, makes it necessary to place the specimen in a new species.

The author is indebted to Dr. C. Richard Robins and Mr. Walter Courtenay, Jr. of The Marine Laboratory, University of Miami, and Al Pfleuger, the well known Miami taxidermist, for the gift of the specimen and information about its host. He wishes to thank Dr. Thomas E. Bowman, Associate Curator, Division of Marine Invertebrates, United States National Museum, who examined the specimen and gave valuable assistance. He is also grateful to Drs. Gilbert L. Voss and John E. Randall of The Marine Laboratory, University of Miami, who read the manuscript and gave many suggestions and to Mrs. Carolyn Lewis who assisted in its preparation.

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Lernaeenicus multilobatus n.sp.

Figure 1, A-J

Holotype. A female, 11.53 mm in total length, preserved in ethyl a cohol, taken from an angler-fish, *Gigantactis* sp., trawled in 385 mete east of New Smyrna, Florida, February 1957 by Capt. Williams of th boat GULF MASTER. USNM 101991.

Type locality.—In 385 meters, east of New Smyrna, Florida.

Description. Dorsally the head is set off from the attachment processe by two slightly convex grooves which run from the anterior end of th head posteriorly to the junction with the neck (Fig. 1-A). A mediar black eye-spot is located 0.23 mm from the anterior edge of the hea (Fig. 1-A). Ventrally the head is covered by the attachment processe (Fig. 1-B). The piercing parts of the mouth are retracted in the spec men and appear only as plates forming a cone which is withdrawn i an oblong sheath that protrudes slightly above the ventral surface c the head, 0.15 mm from the anterior edge (Fig. 1-D). The attachmer processes are basically two lateral lobes, one on either side of th head; the lobes join together just posterior to the mouth; each lob divides into four bulbous parts towards the anterior edge (Fig. 1-B,C)

The slender neck, 0.40 mm in diameter at anterior end, 0.24 mm at posterior, is divided into four segments, each slightly flared at it posterior end. All segments bear a pair of legs projecting ventrally The neck is slightly enlarged at its junction with the head and na rowed at its junction with the trunk (Fig. 1-C).

The cylindrical trunk, 0.20 mm in diameter at anterior end, 0.3 mm at posterior end, has a slightly irregular dorsal surface and enlarged at its junction with the abdomen. The trunk consists of tw indistinct segments of almost equal length; it is easily separated fro both the neck and abdomen (Fig. 1-A).

The ovoid abdomen is of a rudimentary nature, with two protube ances on the posterior end. Indentations are visible on the abdome as shown in Figure 1-A although these are probably due to preserva tion. Egg strings are not present.

First antennae 0.11 mm in length, indistinctly divided into thre segments, without setae, curving down and inward from origin o antero-lateral surface of head. Second antennae 0.2 mm in lengt three-segmented, projecting posteriorly from origin on anterior ve tral surface of head; second and third segments forming a chela (Fi

Fig. 1. A, dorsal view of *L. multilobatus* X2.99. B, Ventral view of attachent processes X8.27. C, lateral view of left side showing neck and attachment rocesses X8.27. D, ventral view of head X39.0. E, second antenna X97.5. F, cond maxilla X97.5. G, first thoracic leg X62.4. H, second thoracic leg X52.0. third thoracic leg X52.0. J. fourth thoracic leg X114.4.

-E). First maxillae three-segmented, without setae, basal segment out, originating at posterior edge of mouth cone; terminal segment rming a short spine. Second maxillae three-segmented, without setae, ender; terminal segment spiniform (Fig. 1-F).

Because of poor preparation of the thoracic leg mount the descripon of the legs should be treated with caution. First thoracic legs unirmose, two-segmented; terminal segment with four disto-lateral setae

(Fig. 1-G). Second thoracic legs biramose, both rami two-segmented first segment of exopod with a spine on distal part of outer margin second segment with a terminal, median, spatulate spine and fou setae; terminal segment of endopod bearing four setae on distal edg (Fig. 1-H). Third thoracic legs not directly attached to the thir thoracic or neck segment but originating from a segmented ring en circling the neck and attached to its dorsal surface, legs uniramose two-segmented; terminal segment of leg bearing two unequal spine and two setae on inner part of distal edge (Fig. 1-I). Fourth thoraci legs biramose, both rami two-segmented; second segment of exopo with four setae on terminal edge and a tooth at distal part of oute margin; terminal segment of endopod with four setae and a tooth a distal part of inner margin (Fig. 1-J).

Measurements. Total length of specimen 11.48 mm; head withou attachment processes 0.83 mm; with processes 2.18 mm. Neck 0.6 mm in length; trunk 1.37 mm; abdomen 7.31 mm.

Color. In alcohol, body brown except for the black eye spot.

Discussion. The ramal make-up of the thoracic legs of *Lernaeenicu multilobatus* differs from that given by Wilson (1932) for the genu *Lernaeenicus* although the validity of this statement is questionabl because of the poor leg mount. The genus description gives the rama count as 2.2,1,1, *L. multilobatus* has a 1,2,1,2 ramal count. Th peculiar make-up of the third thoracic leg is also different from an known members of the genus. Later work may show a need to erec a new genus for those forms with a 1,2,1,2 thoracic leg ramal coun and a third thoracic leg formation similar to *L. multilobatus.*

Remarks. The host was captured at a depth of 210 fathoms; however Grey (1956: 267-269) indicates the vertical range of the gigantactid to be much deeper. Robins and Courtenay (1958) indicate that th host of the new parasitic copepod probably represents an undescribe species. Since the specimen was not deposited in a museum and fron other considerations these workers preferred not to name the specie formally.

The head of the parasite was fastened under the skin on the le side of the host, just posterior to the origin of the pectoral fin, wit the rest of the body trailing outside. A second specimen, presumabl of *L. multilobatus,* was attached to the left side of the host's bod above the anal fin. Unfortunately the second specimen was not give to the author.

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A CONTRIBUTION TO THE LIFE HISTORY OF THE SQUIRREL FISH *HOLOCENTRUS VEXILLARIUS* POEY[1]

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ABSTRACT

The early development of *Holocentrus vexillarius* Poey, 1860 is described from 97 larval, juvenile, and adult specimens ranging from 1.8 to 107.7 mm standard length, from the Gulf of Mexico, the Florida Current, the Western Atlantic, Florida, and the Bahamas. Thirteen specimens representing a size sequence are illustrated. Changes during development, geographical distribution, vertical distribution, spawning, food, and general biology are discussed.

INTRODUCTION

Holocentrus vexillarius Poey belongs to the berycoid family Holo centridae. The various species, commonly called squirrel fishes o soldier fishes, are distributed principally through the warm waters o the Atlantic, Pacific, and Indian Oceans in relatively shallow rock areas and coral formations. They are nocturnal and usually hide i holes during the day.

Late postlarval holocentrids are often referred to as the *"Rhyn chichthys"* stage, a term used in reference to a nominal genus base on the distinctive postlarvae (Figure 7, a and b). Holocentrids in thi stage are common in dipnet collections made over the deep waters o the Gulf of Mexico, the Caribbean Sea, and the Florida Current.

For several years the National Geographic Society - University o Miami Marine Laboratory Pelagic Fish Life History Program ha acquired specimens from plankton tows which are smaller than th *"Rhynchichthys"* stages usually described. Some proved to be *Holo centrus vexillarius*. Adult and juvenile specimens from the Bahama and elsewhere were available in the Marine Laboratory Collection o Fishes.

Since the smaller larvae were taken near shallow water, larger larva in the deep waters of the Florida Current, and *"Rhynchichthys"* stage in the Florida Current, the Gulf of Mexico, and one specimen nort of Bermuda, the species presents an interesting subject for study.

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he larval fish program at the Marine Laboratory, which made this ly possible. Collections of larger juveniles and adults and the nering of notes on their biology is part of a program on the inshore es of the Florida Keys supported by National Science Foundation SF-G-3881). SL stations were occupied in connection with oceanic ductivity studies supported by the Rockefeller Foundation.

Mr. Harvey R. Bullis, Jr., United States Fish and Wildlife Service, dly provided specimens collected in the Gulf of Mexico. Dr. Leon- P. Schultz, Mr. Robert H. Kanazawa, and the staff of the Division Fishes extended many courtesies to the writer during his visit to the ited States National Museum. Dr. Giles W. Mead of the United es Fish and Wildlife Service similarly aided him. Mr. Loren P. ods, Chicago Natural History Museum, loaned specimens and ped in many ways.

The author is deeply grateful to Drs. Gilbert L. Voss, C. Richard bins, Hilary B. Moore, Clarence P. Idyll, and John E. Randall for ice and direction throughout the study and for aid in collection of terial. Finally, many other members of the staff and student body the Marine Laboratory have provided assistance.

Material, Methods, and Terminology

The smaller larvae discussed here are in the larval fish collection at Marine Laboratory. Initially, all larvae were drawn on eight by -inch index cards. All drawings were made the same size, using al length as a basis, regardless of specimen size. Measurements re made and converted to the correct proportions for the predeter- ned size of the drawings. Similar drawings were made of larger cimens which could be identified by fin-ray and scale counts.

This method, established for the larval fish program by Dr. Gilbert Voss and Mrs. Nancy A. Voss, and employed by other workers at Marine Laboratory, has proved very useful. The completed draw- s may be laid out and all viewed at once, including the drawings identified specimens, so that a preliminary series can be established. us, the worker is spared the difficult job of trying to keep in mind many characters, which change with development. Specimens were ividually labeled so that any feature of the drawing could be easily hecked.

The series of specimens identified as *Holocentrus vexillarius,* were examined with particular attention being focused on the characters ich appeared to be important.

The more useful characters in smaller specimens were the two e
larged serrations on the supraoccipital spine, just above its base, and
row of pigment spots on the ventral part of the myotomes posterior
the anus, starting with the fourteenth and proceeding posteriorly. T
pigment spots were found with difficulty in the smallest specimen, b
were quite evident in larger ones. During development other pigme
patterns appear as well as fin elements and scales in later stages. I
dices, when plotted against standard and head lengths and used in co
junction with other characters, were useful in identifying even th
smaller specimens.

Material used for this study comes from several sources and w
collected by several methods. Most larval and all juvenile and adu
specimens are in the fish collection at the Marine Laboratory (UM
ML). Five postlarvae are from the United States National Museu
(USNM). Station data are listed in Table 1.

The designation SL (scattering layer) refers to plankton sampl
taken both for the collection of larval fish and for other concurre
projects. In all instances but one, as far as specimens in this study a
concerned, the SL tows were made about four miles west of Gun Ca
off the northwestern edge of the Great Bahama Bank (ca. 25° 35′ N
79° 25′ W). Here, on the eastern edge of the Florida Current, th
depth is about 740 meters. During 1953 this station was occupied onc
a month for a 24-hour period, unless weather or other circumstance
caused a delay for a longer interval. Since 1953 it has been occupie
less frequently. The exception, SL-37, was taken about ten miles du
east of the Miami sea buoy where the depth is about 200 meters.

Miller *et al.* (1953), N. A. Voss (1954), and Bsharah (1957
have described the methods used to collect specimens and data as we
as the prevailing conditions at the SL station.

The Supl. (supplementary) material was from several sources. Sup
66, 73, 82, 99, and 104 refer to plankton samples taken by sport fish
ing boats in the Bahamas area during the spring of 1956. All wer
surface tows using the same type of net as was used at the SL statio
The closing device was not used. These tows were made along, o
close to, the "drop-off," which is the area along the edge of the Gre
Bahama Bank where the Bank slopes off steeply into the greater depth
of the Straits of Florida. Supl. 122 was a surface plankton tow mad
at a station 10 miles east of the Miami sea buoy. Supl. 153 and 15
were tows made at two to three knots with a two-meter-diameter, larg
mesh net at the regular SL station. Supl. 156 refers to a dip net an

TABLE 1

STATION DATA FOR 97 SPECIMENS OF *Holocentrus vexillarius* POEY.

on	Date	Time	Location	Depth M.	Temp. °C	Sal. ‰	No. of spec.
A-7	3/19/53	1645	25°35′N, 79°25′W	548	11.50	35.35	1
E-0	3/20/53	0800	25°35′N, 79°25′W	0	26.56	35.95	1
B-0	6/12/53	1840	25°35′N, 79°25′W	0	29.56	35.74	1
B-0	7/2/53	0235	25°35′N, 79°25′W	0	28.14	34.90	1
B-4	8/14/53	2135	25°35′N, 79°25′W	360	....	36.77	1
C-0	12/11/53	0647	25°34′N, 79°23′W	0	25.52	36.65	2
A-8	3/25/54	0615	4 Mi W of Gun Cay	338	17.20	35.04	1
C-0	7/8/55	2315	10 Mi. E of Miami	0	30.00	....	1
B-6	5/8/56	2045	25°35′N, 79°22′W	468	13.95	35.82	1
B-8	5/8/56	1930	25°35′N, 79°22′W	687	8.33	35.03	1
A-6	9/13/56	2115	25°35′N, 79°22′W	535	12.46	35.94	1
B-3	4/8/57	0045	25°35′N, 79°22′W	228	19.53	36.83	1
104	6/13/56	1715	edge of drop-off at Sandy Cay	0	27.0	....	12
66	6/5/56	1830	edge of drop-off 2 Mi. S of Bimini	0	28.1	....	1
73	6/6/56	0010	edge of drop-off 2 Mi. S of S Bimini	0	....	....	3
82	6/7/56	1810	edge of drop-off Turtle Rocks	0	....	....	2
99	6/14/56	1815	1 Mi. off Piquet Rock	0	27.1	....	2
122	10/25/56	2115	10 Mi. E of Miami	0	....	....	1
153	6/20/57	0130	25°34′N, 79°35′W	0	....	....	1
154	6/20/57	0330	25°34′N, 79°35′W	35	....	....	1
156	6/20/57	2330	25°34′N, 79°35′W	0	....	....	5
NM 53458	8/29/58	....	37°23′N, 68°08′W	0	26.7	....	1
58128	9/24/54	0300	26°00′N, 88°25′W	0	27.7	....	4
)	8/31/56	....	30°16′N, 80°21′W	0	....	....	1
ML 883	6/7/57	....	Turtle Rocks	..	....	....	33
ML 480	3/17/57	....	Rabbit Keys	..	....	....	8
ML 460	3/5/57	....	Cat Cay	..	....	....	5
ML 2286	7/17/57	....	West Summerland Key, Fla.	..	33.3	....	4

ıt light collection at the SL station. About 140 Supl. plankton ıples were examined for larvae.

The USNM material is from two sources. USNM 163458 was col-ed by the U. S. Fisheries Steamer ALBATROSS probably by dip net ce the label with the specimen refers to "surface" and electric light." e rest of the USNM material referred to in this work was collected the U. S. Fish and Wildlife Service vessel OREGON by dip net and ht light in the Gulf of Mexico.

TABLE 2

Holocentrus vexillarius POEY. MERISTIC DATA.*

Station	Std. L.	Scales in lateral line with tubes	Dorsal-fin rays	Anal-fin rays	Pectoral-fin rays	Pelvi fin ray
SL 19 B-4	7.8	..	13	9	..	
SL 24 A-8	8.5	..	13	9	..	
USNM 163458	15.8	43	13	9	15	
SL 37 C-0	15.9	43	13	9	15	
Supl. 154	17.5	41	13	9	15	
Supl. 153	17.9	42	13	9	15	
USNM 158128	20.3	41	13	9	15	
"	20.5	43	13	9	15	
Supl. 156	20.8	42	14	9	15	
"	21.9	41	13	9	15	
"	23.5	43	13	9	15	
USNM 158128	24.0	41	13	9	15	
"	24.2	43	13	9	15	
C-70	24.5	41	13	9	15	
Supl. 156	24.5	43	14	9	15	
"	24.9	43	13	9	15	
UMML 883	30.5	41	13	9	15	
"	31.5	41	13	9	15	
"	32.5	42	13	9	15	
"	33.5	41	14	9	15	
"	33.5	41	13	8	15	
UMML 460	47.0	43	13	9	15	
UMML 2268	55.8	40	13	9	15	
UMML 480	57.2		13	10	15	
UMML 2268	60.0	43	13	8	15	
"	61.0	43	13	9	15	
UMML 883	62.3	41	13	9	15	
UMML 2268	63.5	41	13	8	15	
UMML 883	65.5	40	13	9	15	
UMML 480	66.0	41	13	9	15	
UMML 883	66.0	43	13	9	15	
"	66.5	42	13	9	15	
"	67.0	42	13	9	15	
"	67.5	42	13	9	15	
"	67.5	41	13	9	15	
"	68.0	42	14	10	15	
UMML 480	68.5	43	13	9	15	
UMML 460	70.8	41	13	9	15	
"	71.0	42	13	9	15	
UMML 883	71.0	41	13	9	15	
"	74.0	44	13	9	15	
"	74.5	42	13	9	15	

TABLE 2—*Continued*

Holocentrus vexillarius POEY. MERISTIC DATA.*

tation	Std. L.	Scales in lateral line with tubes	Dorsal-fin rays	Anal-fin rays	Pectoral-fin rays	Pelvic-fin rays
ML 460	76.0	40	13	9	15	7
ML 883	76.0	41	14	9	15	7
"	82.0	41	13	9	15	7
"	85.0	41	13	9	15	7
"	85.0	41	13	9	15	7
ML 480	85.5	42	13	9	15	7
ML 460	87.6	43	13	9	15	7
ML 883	88.4	42	13	9	15	7
"	90.0	42	13	9	15	7
"	90.7	42	13	9	15	7
"	91.2	42	14	9	15	7
ML 480	91.3	42	13	9	15	7
ML 883	93.0	42	14	9	15	7
"	95.0	41	13	9	15	7
"	95.0	42	13	9	15	7
"	95.0	42	13	9	15	7
ML 480	96.3	43	13	9	15	7
ML 883	97.5	45	13	9	15	7
ML 480	99.5	44	13	9	15	7
"	99.8	43	13	9	15	7
ML 883	101.0	42	13	9	15	7
"	104.0	41	13	9	15	7
"	105.6	41	13	9	15	7
"	107.7	42	13	9	15	7

y soft-ray counts are given for the fins. All specimens had dorsal spine nts of XI, anal spine counts of IV, and pelvic spine counts of I.

pecimen C-70 was taken by dip net and night light by the U. S. and Wildlife Service vessel COMBAT.

uveniles and adults were collected by poisoning at various stations ne Bahamas and the Florida Keys.

maller specimens were measured with an optical micrometer. Since preopercular spines of these specimens protrude, it was necessary lace a glass slide over the animal to depress the spines so that ac- ate measurements could be made. The slide was raised at each end putting separators under it in order not to flatten the body of the cimen. The larger specimens were measured with calipers. All surements are given in millimeters, and all measurements and nts were taken from the left side of the specimen unless that side

was damaged. Counts are given in Table 2.

Indices are percentages of standard length, or of head length, ar are given in Table 3. These indices were plotted on graph paper ar trend lines were added.

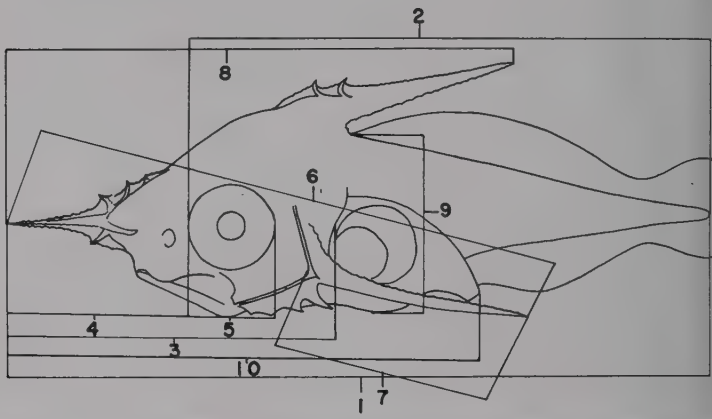


FIGURE 1. *Holocentrus vexillarius* Poey. Diagram showing the measureme taken and designating each one by a number.

Figure 1 shows the measurements used and their limits and ind cates each one by a number. These numbers are used in the colum headings in Table 3. The measurements indicated by the numbers Figure 1 are referred to in the text as follows:

1. *Standard length* is measured from the tip of the snout, includi the rostral spine when present, to the tip of the vertebral column. specimens in which the end of the vertebral column has turned u the measurement is to the caudal base.

2. The *anterior margin of the orbit to the tip of the vertebral colum* is measured from the most anterior point on the inside margin of t orbit to the end of the vertebral column, or to the middle of the caud base.

3. *Head length* is measured from the tip of the snout, including t rostral spine when present, to the most posterior edge of the opercl but does not include either the opercular, or the preopercular, spines

4. *Snout length* is measured from the tip of the snout, including t rostral spine when present, to the inside margin of the orbit.

TABLE 3

olocentrus vexillarius POEY. BODY PROPORTIONS OF LARVAL, JUVENILE, AND DULT SPECIMENS EXAMINED. (SEE TEXT AND FIGURE 1 FOR THE MEANING OF THE NUMBERS HEADING THE COLUMNS.)

		Per cent of standard length							Per cent of head length	
ion	Std. L.	2	3	4	6	8	9	10	5	7
l. 104	1.8	91.7	27.8	8.3	44.4	37.2	28.9	42.7	46.0	66.0
l. 104	2.1	93.0	27.1	7.2	40.5	34.3	26.2	47.5	47.4	58.0
l. 82	2.1	92.5	31.4	8.5	50.7	47.0	31.9	57.7	44.8	71.6
l. 99	2.2	91.0	32.2	8.3	55.4	44.7	28.1	49.7	40.0	83.0
l. 104	2.2	94.0	28.6	5.9	46.0	43.2	26.4	45.5	44.4	76.7
l. 104	2.2	89.7	32.7	10.3	58.4	45.4	26.9	53.0	41.2	82.2
l. 104	2.2	91.0	30.0	7.6	49.7	44.0	28.2	49.7	44.8	71.7
l. 104	2.3	90.0	31.3	10.0	48.3	43.9	28.2	52.3	41.7	59.7
14, A-7	2.3	96.6	32.2	8.6	53.7	50.7	32.2	50.2	44.1	64.0
l. 99	2.6	87.5	39.8	12.7	61.5	54.0	28.0	60.5	37.6	78.5
18, C-O	2.8	84.7	40.0	18.5	70.5	69.2	27.5	63.3	33.9	80.3
l. 104	3.0	84.0	35.0	14.5	58.3	57.3	25.9	51.5	34.6	78.3
l. 73	3.0	81.0	40.3	17.3	70.7	. . .	25.7	58.4	33.1	76.7
l. 104	3.2	82.0	38.8	18.0	69.5	67.3	26.2	57.7	32.5	81.4
l. 73	3.2	78.2	43.7	21.9	76.0	76.0	27.7	61.5	30.7	78.5
23, C-O	3.2	90.6	36.3	12.5	59.4	56.6	25.0	56.3	38.9	71.5
l. 66	3.3	72.7	47.6	24.2	82.7	72.8	26.3	69.7	27.4	78.5
l. 104	3.4	82.5	37.6	18.2	66.2	64.3	23.5	55.2	31.3	83.6
l. 73	3.4	73.5	45.0	25.0	77.0	79.5	26.5	64.2	28.7	78.5
l. 104	3.5	77.3	42.8	22.6	72.0	68.7	26.3	60.0	29.3	73.4
l. 122	3.6	75.0	45.3	25.0	72.8	75.0	25.0	59.7	26.4	67.5
23, C-O	3.7	80.6	38.7	19.7	67.6	66.3	24.3	54.2	31.5	77.0
l. 104	3.8	76.6	43.0	21.8	68.5	71.2	24.2	64.7	29.4	67.5
17, B-O	3.8	77.6	48.5	21.6	74.0	72.5	23.7	62.5	25.5	62.5
l. 104	4.3	74.5	42.6	25.6	74.5	76.8	23.3	59.3	24.6	72.7
14, E-O	5.0	73.0	44.0	26.0	74.0	76.0	24.0	60.0	27.3	68.3
45, A-6	5.8	73.3	48.3	27.6	78.0	79.2	22.4	66.5	25.0	66.5
44, B-6	6.8	72.2	48.5	27.9	76.5	73.5	22.1	67.7	24.8	65.3
44, B-8	6.9	72.5	48.5	27.6	75.5	71.3	20.3	68.6	24.5	63.4
47, B-3	7.3	71.8	52.7	28.4	81.2	77.0	23.0	73.0	25.1	62.4
19, B-4	7.8	71.8	50.0	28.2	74.5	73.0	23.1	71.8	24.8	59.0
24, A-8	8.5	70.6	52.4	30.6	71.8	80.0	22.3	75.3	22.5	49.5
NM 163458	15.8	76.5	50.6	23.4	58.7	47.5	31.6	72.7	28.8	35.0
37, C-O	15.9	70.6	52.5	31.2	67.0	. . .	26.2	80.0	23.8	41.7
pl. 154	17.5	77.3	53.5	28.0	58.9	. . .	29.7	72.6	23.4	27.8
pl. 153	17.9	80.0	49.7	25.1	59.3	50.7	31.2	77.3	26.9	39.4
NM 158128	20.3	79.9	47.4	20.1	50.6	44.7	31.5	77.9	27.1	31.3
NM 158128	20.5	83.5	45.3	16.6	46.3	41.5	32.5	72.7	30.1	26.9
pl. 156	20.8	81.7	45.7	24.0	48.2	47.5	27.4	74.5	24.2	35.8
pl. 156	21.9	83.2	43.4	20.1	50.3	42.4	30.1	73.2	31.6	37.9
pl. 156	23.5	84.0	42.2	19.2	46.5	40.4	28.1	72.5	29.9	36.1

TABLE 3—*Continued*

Holocentrus vexillarius POEY. BODY PROPORTIONS OF LARVAL, JUVENILE, AN ADULT SPECIMENS EXAMINED. (SEE TEXT AND FIGURE 1 FOR THE MEANING OF THE NUMBERS HEADING THE COLUMNS.)

		Per cent of standard length							Per cent of head length	
Station	Std. L.	2	3	4	6	8	9	10	5	7
USNM 158128	24.0	88.4	38.3	11.7	41.3	37.5	31.6	69.6	32.6	33.
USNM 158128	24.2	87.2	41.4	12.7	43.7	36.8	31.0	70.4	31.0	31.
C-70	24.5	88.5	38.8	15.9	41.3	37.5	29.4	73.0	29.5	35.
Supl. 156	24.5	85.4	40.4	17.1	43.3	38.8	28.6	70.7	30.3	35.
Supl. 156	24.9	83.5	40.2	14.1	41.0	36.9	30.1	70.5	31.0	27.
UMML 883	30.5	93.5	37.7	8.2	33.1	35.1	33.8	70.0	39.2	30.
UMML 883	31.5	93.0	35.6	7.6	31.8	32.2	35.3	70.0	37.5	26.
UMML 883	32.5	94.0	37.0	8.3	33.8	33.8	35.4	69.4	40.7	29.
UMML 883	33.5	93.3	36.2	9.0	28.6	34.4	36.1	71.5	34.7	24.
UMML 883	33.5	91.6	33.1	7.2	33.7	33.5	34.4	67.7	43.3	30.
UMML 460	47.0	95.0	37.7	8.6	32.3	33.0	36.8	69.6	41.2	26.
UMML 2268	55.8	94.6	34.9	9.0	30.5	31.2	38.2	71.7	40.0	18.
UMML 480	57.2	92.7	36.2	10.7	31.5	34.2	38.9	69.7	43.4	21.
UMML 2268	60.0	94.7	34.7	8.7	30.0	30.5	36.7	70.0	38.0	22.
UMML 2268	61.0	92.0	34.4	8.2	30.7	31.0	36.6	69.7	37.1	22.
UMML 883	62.3	94.0	37.0	7.9	31.5	30.7	37.2	69.6	38.7	24.
UMML 2268	63.5	93.3	35.0	8.4	28.7	29.5	37.8	69.4	37.4	18.
UMML 883	65.5	93.0	35.9	8.4	29.5	30.6	37.4	69.7	35.6	21.
UMML 480	66.0	92.5	37.9	9.6	30.5	31.5	38.7	69.7	36.8	22.
UMML 883	66.0	94.0	36.4	8.7	30.3	31.5	37.2	67.2	39.6	23.
UMML 883	66.5	94.5	37.6	9.0	30.1	31.7	37.3	70.0	36.6	19.
UMML 883	67.0	98.8	35.0	8.7	30.6	30.6	37.8	69.5	39.7	24.
UMML 883	67.5	93.5	35.3	9.2	31.9	31.2	37.5	66.6	39.8	23.
UMML 883	67.5	94.8	36.3	8.8	29.9	31.5	37.4	68.0	38.7	21.
UMML 883	68.0	94.9	35.8	8.8	31.6	31.6	36.8	69.3	40.7	20.
UMML 480	68.5	95.1	35.4	9.4	30.5	30.7	35.8	68.6	38.9	23.
UMML 460	70.8	94.4	34.9	8.2	29.8	31.1	36.7	67.7	33.6	20.
UMML 460	71.0	94.3	34.2	7.5	29.3	30.0	37.8	67.0	35.8	21.
UMML 883	71.0	94.5	34.9	7.8	29.6	30.7	35.5	66.7	38.3	22.
UMML 883	74.0	91.3	34.5	8.4	30.2	29.5	36.6	67.6	39.3	22.
UMML 883	74.5	94.0	33.9	8.2	29.9	29.0	35.1	66.4	38.9	23.
UMML 460	76.0	94.5	35.3	7.9	31.2	30.0	37.5	68.3	39.2	22.
UMML 883	76.0	92.5	35.6	8.2	31.3	29.6	37.4	67.2	38.2	23.
UMML 883	82.0	94.0	34.8	8.3	29.3	30.1	35.4	67.5	39.3	21.
UMML 883	85.0	93.5	35.9	8.3	31.0	30.2	36.5	69.1	37.8	22.
UMML 883	85.0	94.2	34.8	8.6	31.2	29.4	36.8	68.1	36.8	23.
UMML 480	85.5	92.5	35.5	9.4	30.5	31.6	40.0	72.5	39.6	21.
UMML 460	87.6	91.3	35.6	9.1	28.5	28.9	31.7	67.4	36.6	21.
UMML 883	88.4	94.9	35.4	8.3	30.6	27.4	36.0	68.5	38.0	23.
UMML 883	90.0	92.7	35.6	9.7	30.0	31.2	35.3	70.5	37.5	21.
UMML 883	90.7	93.6	34.2	7.7	29.3	28.6	34.8	68.4	36.8	19.

TABLE 3—*Continued*

locentrus vexillarius POEY. BODY PROPORTIONS OF LARVAL, JUVENILE, AND DULT SPECIMENS EXAMINED. (SEE TEXT AND FIGURE 1 FOR THE MEANING OF THE NUMBERS HEADING THE COLUMNS.)

		Per cent of standard length							Per cent of head length	
tion	Std. L.	2	3	4	6	8	9	10	5	7
MML 883	91.2	93.3	34.6	8.8	30.7	29.3	36.0	69.4	37.8	21.9
MML 480	91.3	94.0	34.5	8.6	30.5	30.1	36.5	69.4	39.7	23.1
MML 883	93.0	93.0	34.6	8.2	31.6	30.3	37.1	69.5	37.9	25.8
MML 883	95.0	93.8	35.4	8.4	30.7	30.3	37.4	60.2	38.4	20.8
MML 883	95.0	97.0	36.4	8.2	31.4	31.1	37.8	70.0	37.4	23.7
MML 883	95.0	93.7	33.8	7.9	29.4	28.4	35.8	69.0	37.4	20.9
MML 480	96.3	93.0	35.6	10.0	30.9	31.4	37.5	67.5	37.9	25.0
MML 883	97.5	94.2	35.6	8.3	33.8	23.8	36.9	70.5	37.5	20.5
MML 480	99.5	93.7	34.8	9.0	30.7	29.2	35.9	69.3	37.0	23.4
MML 480	99.8	92.7	34.3	8.6	30.8	29.6	35.4	68.0	36.3	23.4
MML 883	101.0	93.3	34.0	8.9	32.0	28.9	35.1	68.7	41.2	24.8
MML 883	104.0	92.4	33.9	9.2	29.8	28.6	35.4	71.5	36.3	21.8
MML 883	105.6	92.7	33.5	9.3	29.8	29.4	35.5	71.3	37.3	20.0
MML 883	107.7	94.5	33.9	8.3	30.5	28.3	35.3	69.5	35.6	21.9

5. *Eye diameter* is the inside, horizontal diameter of the orbit.

6. The measurement from the *tip of the snout to the tip of the eopercular spine* includes the rostral spine when present.

7. *Preopercular spine length* is measured from the angle of the eopercle to the tip of the preopercular spine.

8. The measurement from the *tip of the snout to the tip of the praoccipital spine* includes the rostral spine when present. After e supraoccipital spine, as such, is no longer apparent, the measure-ent is to the posterior tip of the median ridge in the supraoccipital gion, which is the remnant of this spine.

9. *Body depth* is measured from the dorsal origin of the finfold, or om the first dorsal spine when it appears, directly ventrad, to the ntral profile of the body.

10. *Preanal length* is measured from the tip of the snout, including e rostral spine when present, to the ventral origin of the finfold, or the first anal spine when it appears.

The counts are as defined by Hubbs and Lagler (1947, pp. 8-13), less otherwise noted. Only fully formed fin elements were counted.

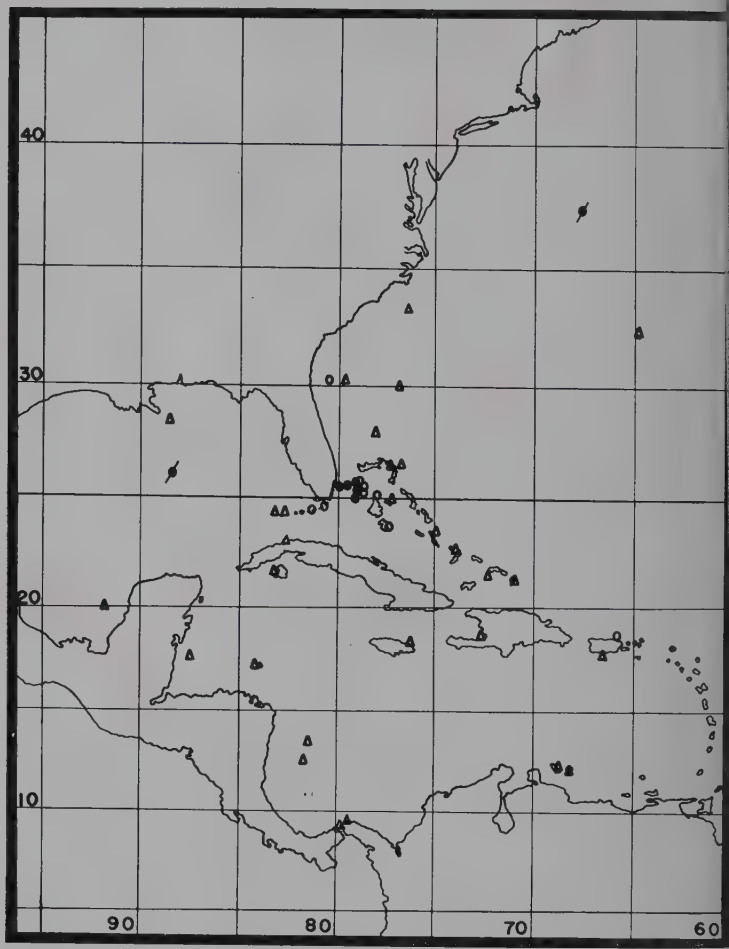
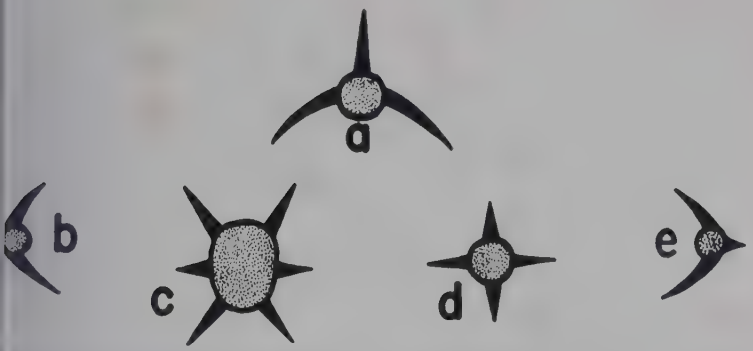


FIGURE 2. Geographical distribution of *Holocentrus vexillarius* Poey.

All scales in which lateral-line pores were visible were counted.

Terminology used for the larval stages is that proposed by Hubbs (1943). Of the 97 specimens examined, two were prolarvae, 45 were postlarvae, five were juveniles (between 24.9 mm and 47.0 mm), and



GURE 3. Diagram of cross-sections of the major spines of larvae of *Holo-ntrus vexillarius* Poey. a—supraoccipital, b and e—preopercular, c—rostral se to head, d—rostral close to tip.

were adults. The total size range is from 1.8 mm to 107 mm stan-rd length. Other UMML specimens were identified and used in otting distributional records. Data for these specimens are listed in e section concerned with distribution.

References to Young Holocentrids

References to postlarval holocentrids are of long standing and are latively frequent. The first description in Cuvier and Valenciennes tablished the genus *Rhynchichthys* Valenciennes, 1831 for a speci-en from the Indian Ocean. Woods (1955) considered the type, *R. lamidis* Valenciennes (Cuv. and Val., 1831, pl. 208), to be a post-rval specimen of some species of *Myripristis*. He based his con-usions on dorsal and anal fin-ray counts which are X, I, 12 and IV, 2 respectively.

Günther (1859) listed three species of the genus *Rhynchichthys*. llowing this, Gill (1862 and 1863) established the genera *Rhino-ryx* and *Rhamphoberyx*. Woods (1955) considered the type of *hinoberyx*, which is *Rhynchichthys brachyrynchus* Bleeker, a post-rva of some species of *Myripristis*. He also synonymized *Rhinoberyx ryseus* Cope with *Myripristis jacobus*. Gilbert and Starks (1904), eek and Hildebrand (1923), and Woods (1955) all considered the ecies placed in the genus *Rhamphoberyx* to belong in *Myripristis*.

Lütken (1880) first noted that these three nominal genera, *Rhyn-ichthys, Rhinoberyx,* and *Rhamphoberyx,* were based on the young other genera of holocentrids, although he did not allocate any of

them. He described specimens obtained on his voyage to the Caribbea and figured seven. Three specimens (Lütken, 1880, Figs. 1-3, pl. II he considered to be *Holocentrum marianum* C.V., probably referrin to *Holocentrus marianus* Cuvier. The two larger specimens figured i this series show a black spot on the anterior part of the first dors which is similar to that of inshore specimens of *H. coruscus,* althoug in the copy of this work available to the writer, other features such a fin rays are not clear. Since his figures appear to represent pelag stages, coloration is probably not the same as that of inshore spec mens. Lütken also described, in considerable detail, the spines of h specimens and noted their changes with growth. Since Lütken, la postlarvae of the holocentrids have often been referred to as in th *"Rhynchichthys"* stage.

Following Lütken's work numerous records, descriptions, and fi ures have appeared, but they are nearly all of one or two specimer and are scattered throughout the literature. Fowler (1944, p. 99) d scribed the colors of some specimens 37 to 46 mm standard lengt identified by him as *H. vexillarius,* and figured one about 40 mm lor which still had the remnants of the rostral spine. They are discusse elsewhere in this paper. Beebe and Tee-Van (1928) may have had tw late postlarvae or juveniles of *H. vexillarius* which they identified a *H. coruscus.* The writer has not seen these specimens and to his know edge there has been no work covering a considerable size range of ar holocentrid.

Development

Specimens Studied. Twenty-eight specimens (1.8-24.9 mm standard lengt from nine supplementary stations along the edge of the Great Bahama Bank a in the Florida Current (complete data given in Table 1.)

Thirteen specimens (2.3-15.9 mm standard length) from 12 regular S stations (complete data given in Table 1).

One specimen USNM 163458 (15.8 mm standard length) from ALBATRO station 2566, August 10, 1885, surface, by dip net and electric light, 37°23′ 68°08′W.

Four specimens USNM 158128 (20.3-24.2 mm standard length from M OREGON station 1193, 0100-0500 hours, September 24, 1954, surface by dip n 26°00′N, 88°25′W.

One specimen (24.5 mm standard length) from M/V COMBAT station 7 August 31, 1956, surface by dip net, 30°16′N, 80°21′W.

Thirty-three specimens UMML 883 (30.5-107.7 mm standard length) fro a poison station in "cay rock" tide pools, Turtle Rocks, three miles south South Bimini, Bahamas, June 7, 1957.

Eight specimens UMML 480 (57.2-99.8 mm standard length) from a pois station in rocky tide pools, Rabbit Keys, just south of South Bimini, Bahama March 17, 1957.

Five specimens UMML 460 (47.0-87.6 mm standard length) from a poison tion in rocky tide pools, Cat Cay, Bahamas, March 5, 1957.
Four specimens UMML 2268 (55.8-63.5 mm standard length) from a poison tion at West Summerland Key, ¼ mile south of Bahia Honda Bridge, Flor-a, August 17, 1957.

8 mm specimen (Figure 4a). The smallest available specimen, 1.8 m standard length, is carrying a small amount of yolk. The head is irly large, 27.8 per cent of standard length with a prominent eye, 46 r cent of head length, and a blunt snout, 8.3 per cent of standard ngth. The eye is not round and has a ventral fissure. There is a ser-ted spine at the angle of each preopercle, (length, 66 per cent of ad length). The length from the tip of the snout to the tip of this ine is 37.2 per cent of standard length. The lower limb of the pre-ercle is armed with two recurved spines. Dorsally, in the supraoc-pital area, two spikes project from an elevated base. These spikes are e first indications of the complex supraoccipital spine. The measure-ent from the snout to the tip of the posterior supraoccipital spike is .4 per cent of standard length.

The mouth is terminal and oblique and extends almost to the pupil the eye. Details of the jaws were seen with difficulty in the smaller ecimens.

The viscera is sac-like in appearance and the anus points posteriorly. orsally this sac is heavily pigmented, but the pigment decreases along e sides and posteriorly leaving the ventral part of the sac unpig-ented. Body depth is 28.9 per cent of standard length.

The body is slender and tapered. The vertebral column is straight roughout most of its length, but slopes upward over the viscera. aint pigmentation was present in the ventral part of the myotomes osterior to the anus, but this may be an artifact. The myotomes are stinct anteriorly, but are indistinct in the caudal region. Twenty-four ere counted.

The only differentiated fins are the pectorals, with a large fleshy base id no detectable rays. The median fin-fold is continuous, with a dip orsally and ventrally in the caudal region. The fold starts just posterior the head dorsally and extends to the anus. The fin-fold in this speci-en was damaged. The portions not actually seen are drawn with ashed lines on the figure.

2 mm specimen (Figure 4b). Over an increase in length of 0.4 mm a standard length of 2.2 mm, considerable development takes place. ead length has increased slightly to 32.7 per cent of standard length id indications of the rostral spine can be seen. The anterior profile

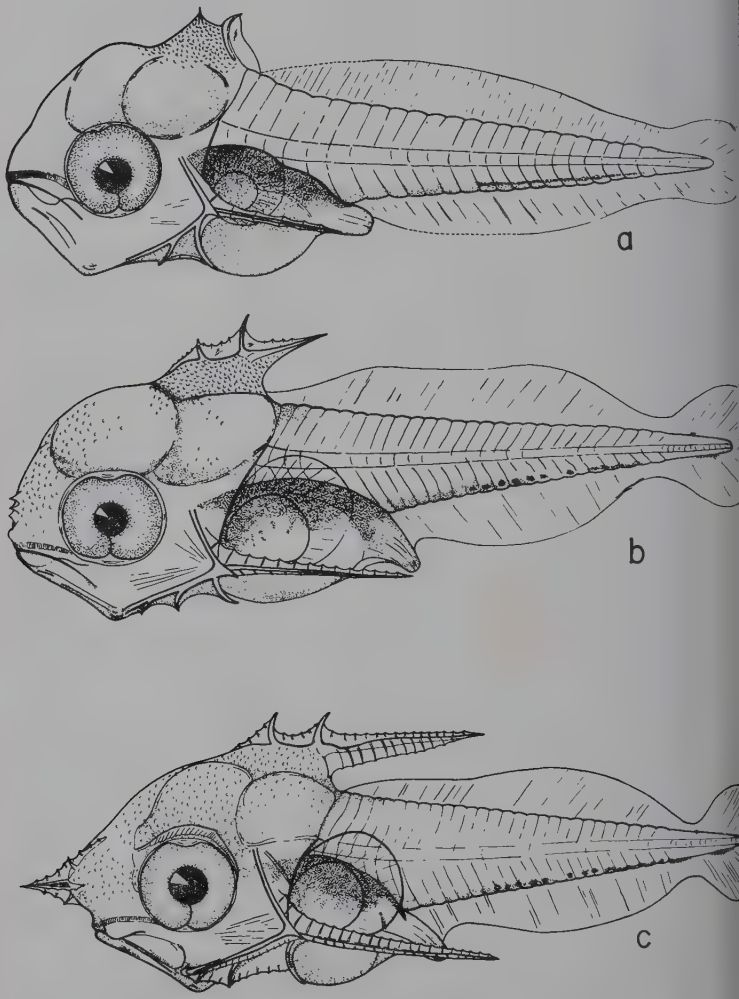


FIGURE 4. *Holocentrus vexillarius* Poey. a—1.8 mm, b—2.2 mm, c—2.8 mm

he snout is less blunt than in the former specimen and its length increased to 10.3 per cent of standard length. The eye continues to prominent, but its diameter has decreased relative to head length 41.2 per cent. It is still not round. The preopercular spine is 82.2 cent of head length and measured from the tip of the snout it is 4 per cent of standard length. This is a substantial increase of both ices. Accompanying this increase in relative length, is an increase the number of cross ribs on these spines. The lower limb of the opercle now bears three spines instead of two as it did in the 1.8 n specimen. The number of these spines will show a further increase development proceeds. The spine adjacent to the major spine at the gle will continue to be the best developed of these spines on the er limb of the preopercle.

The supraoccipital spine now has all of its major elements and its e has lengthened considerably. The posterior spike has elongated d grown out almost parallel to the dorsal profile of the body. A third ke has appeared anterior to both of those present in the 1.8 mm cimen. The distance from snout tip to the tip of the supraoccipital ne is 58.4 per cent of standard length. All spikes are connected sally by a serrated, bony membrane.

The visceral sac has not changed in pigmentation, but is relatively ger and the anus is directed more ventrad than before. Depth is now .9 per cent of standard length.

There has been some body development. The most posterior myo-nes are more distinct and pigment spots are definitely present in the ntral portion of some of the myotomes posterior to the anus. The t of these spots is in the fourteenth myotome.

Aside from some relative enlargement of the pectoral fins and deeper tches in the caudal region of the median fin-fold, there has been no ticeable development of the fins.

mm specimen (Figure 4c). In this specimen the most notable anges have occurred in the snout region. The snout now projects, erhangs the inferior mouth, and possesses a complex spine. Snout gth, which includes this spine, is 18.5 per cent of standard length. ad length, also including this rostral spine, has increased nearly 8 cent and is now 40.0 per cent of standard length. Since the rostral ne has increased head length, the relative diameter of the eye, which till not quite round, has decreased to 33.9 per cent of head length. supraorbital, serrated crest has developed. The maxillary can be re clearly distinguished than in the smaller specimens, and it extends

well back beneath the eye, almost to the center of the pupil. The pr opercular spine is 80.3 per cent of head length, and measured from th tip of the snout, its length has increased to 69.2 per cent of standar length. The supraoccipital spine has also increased in relative lengt Measured from the tip of the snout it shows an increase of 12.1 pe cent and is 70.5 per cent of standard length. This spine has develope cross ribs similar to those of the preopercular spines.

The visceral sac is slightly smaller in relative size, but shows n change in pigmentation. Body depth remains about the same at 27. per cent of standard length.

No pigmentation is evident that was not present on the 2.2 mr specimen, and the developing fins show no significant change.

4.3 mm and 5.0 mm specimens (Figures 5a and 5b). In general, th trends of development noted in the last three specimens figured cor tinue in the next two specimens. The slope of the snout is less stee than in the preceding specimens. Head length has increased to 44 pe cent of standard length, due largely to the more projecting snout an its spine. Snout length is now 26 per cent of standard length in th 5.0 mm specimen. Eye diameter in head length has decreased to 27. per cent. Preopercular spine length in head length has also decrease to 68.3 per cent. The measurement from the tip of the rostral spine t the tip of the preopercular spine and the measurement from the tip o the rostral spine to the tip of the supraoccipital spine have increased t 74 per cent and 76 per cent of standard length respectively in the 5.(mm specimen. Depth in standard length has decreased to 24 per cent

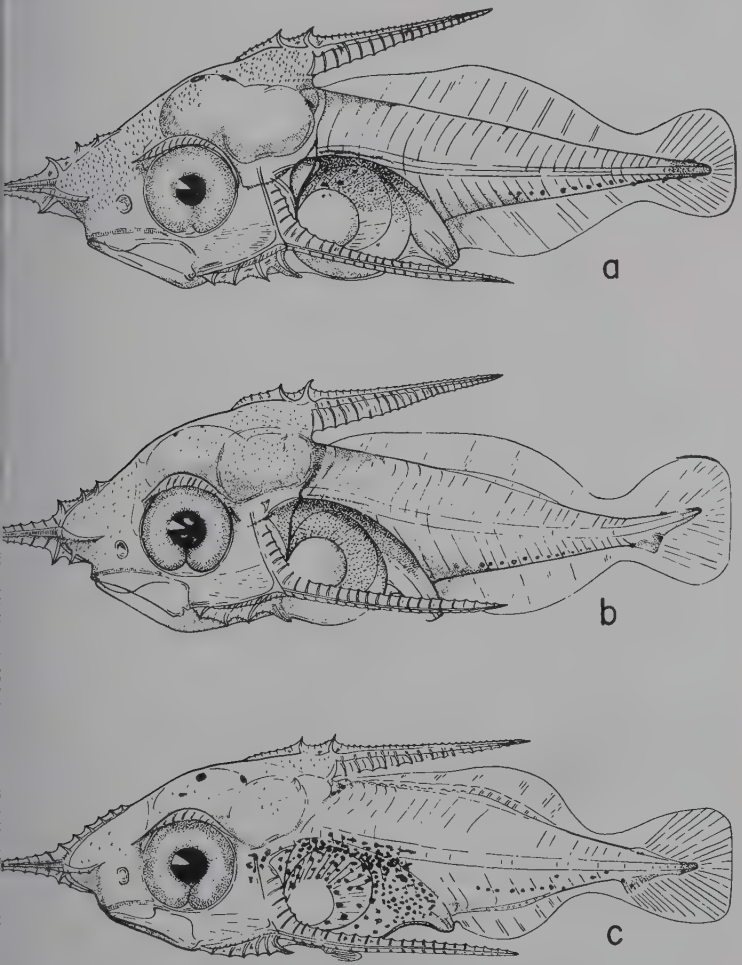
The nares appear in both of these specimens as single opaque area on the snout. An opercular spine is also present in both of these speci mens just dorsal to the viscera and in the 5.0 mm specimen there is spine in the dorso-posterior region of the head and another dorsal t the preopercular spine. The lower limb of the preopercle now has fou spines and all of them are becoming relatively smaller.

Several large chromatophores are present on the dorsal part of th head of these specimens and there is evidence of pigment on the viscera sac breaking up in the 4.3 mm specimen. This latter feature was no apparent in the 5.0 mm specimen figured. A small streak of pigmen has also appeared along the vertebral column, in the portion of i dorsal to the viscera.

The first indication of a median fin is present in the 5.0 mm speci men. In the area where the base of the soft dorsal will be, there is thickening of the tissues. In this same specimen, the end of the vertebra

mn has turned up and elements of the urostyle as well as develop-
soft rays can be seen. The pelvics have not appeared, but the pec-
ls are relatively smaller and their fleshy base occupies less of them
it formerly did.

mm, 7.3 mm, 7.8 mm, and 8.5 mm (Figures 5c, 6a, 6b, and 6c).

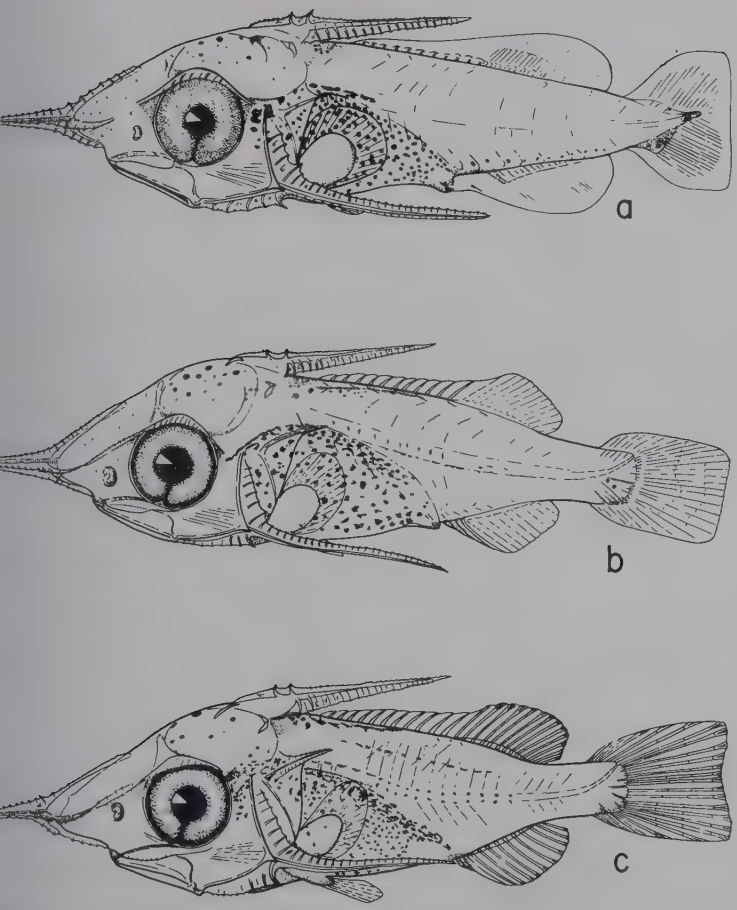


URE 5. *Holocentrus vexillarius* Poey. a—4.3 mm, b—5.0 mm, c—5.8 mm.

With the appearance of the pelvic fins at a size between 5.0 mm a 5.8 mm, the basic features that the animal will have in the pela phase are present. Head length in standard length increases from per cent in the 5.8 mm specimen to 52.4 per cent in the 8.5 mm spe men. Snout length in standard length continues to increase, amounti to 30.6 per cent in the 8.5 mm specimen, and eye diameter in he length to decrease to 22.5 per cent in this same specimen. The leng of the preopercular spine decreases rapidly in head length from 6 per cent in the 5.8 mm specimen to 49.5 per cent in the 8.5 mm a mal. The measurement from the tip of the snout to the tip of t preopercular spine increases in the 5.8 mm specimen to 79.2 per ce of standard length and thereafter decreases gradually. This index 71.3 in the 7.3 mm specimen, 73.0 in the 7.8 mm specimen, and 7 in the 8.5 mm specimen. The measurement from the tip of the snout the tip of the supraoccipital spine shows a similar increase in its ind in the 5.8 mm specimen and then a decrease in the next three spe mens under consideration. Body depth does not change much relati to standard length. It ranges from 20.3 per cent of standard length the 7.3 mm specimen to 23.1 per cent in the 7.8 mm specimen.

The nares remain single up through the 8.5 mm specimen, but b come more strongly marked. The opercular spine, first noted in the 5 mm individual, becomes more prominent in these larger animals a acquires a ribbed appearance similar to the three major spines. A s rated ridge appears in the 7.8 mm specimen. This is located above t posterior margin of the eye on the crown and is the first of many su ridges. The lateral ridges of the rostral spine lengthen posteriorly a dorsally along the sides of the snout, and become continuous with t supraorbital crest in the 7.8 mm specimen.

There is an increase in the amount of pigment and in the areas i volved in these specimens. The pigment of the visceral sac, which w diffuse in the 5.0 mm specimen, and becoming arranged in chromat phores in the 4.3 mm specimen figured, is concentrated in chromat phores in all of the specimens from 5.8 mm to 8.5 mm. In addition the pigment noted in the 5.0 mm specimen (Fig. 5b), pigment appea on the dorsal part of the body posterior to the head in the 5.8 m specimen, and about midway between the vertebral column and t dorsal profile in the 8.5 mm specimen. In the 8.5 mm specimen t pigment along the vertebral column appears in a dorsal and a vent row. The pigment spots themselves seem to be between the vertebra The row of pigment spots, which is present posterior to the anus in t



RE 6. *Holocentrus vexillarius* Poey. a—7.3 mm, b—7.8 mm, c—8.5 mm

ller specimens, becomes obscure in the 7.8 mm and 8.5 mm speci-
s. This is probably due to the thickening body musculature. Ob-
ations made on the 7.3 mm specimen just after it was taken, and
e still alive, revealed that the pigment is dark brown and that the
of the body is transparent or translucent.

The median fin-fold is discontinuous with the caudal fin in the 7. mm specimen, and in the 7.8 mm and 8.5 mm specimens there is definite caudal peduncle. Dorsal-, anal-, and caudal-fin rays are prese in the 5.8 mm and 7.3 mm specimens, but the definitive number is n yet present, nor are the rays fully formed. In the 7.8 mm specimen, th rays are all present and the longer caudal rays have two articulation In the 8.5 mm specimen, the rays in the dorsal and anal fins hav begun to branch and the longer caudal fin rays have three articula tions. The last dorsal and anal spines appear similar to soft rays at firs The soft dorsal and anal fins have a truncate appearance in the 7. mm specimen, and in the 8.5 mm specimen the caudal shows indica tions of becoming forked.

Pelvic fins are present in the 5.8 mm specimen, but are only flesh stubs. The pectoral fins remain quite rounded up until the stage repre sented by the 7.3 mm specimen and then become more tapered. Pe toral-fin rays are present in the 5.8 mm specimen, but the author ha difficulty in counting them even in the 8.5 mm specimen.

There is a gradual thickening of the body wall in these specimen and a notable deepening posterior to the anus, so that by the stage o development represented by the 8.5 mm specimen, the anus no longe protrudes.

Scales are noticeable in the 8.5 mm specimen, but the author wa unable to count them. They are not included in Figure 6c.

15.9 mm specimen (Figure 7a). The next specimen in this series is 15. mm in standard length. This is an increase in standard length of 7. mm, and the specimen shows considerable advances in developme over the preceding stages. Body shape is becoming more like that o the adult, in that its depth is increasing, especially in the posteri region. The dorsal and ventral profiles of the body still slope posteriorl but the caudal peduncle is better defined than before. Body depth now 26.5 per cent of standard length. Head length in standard leng remains about the same as in the 8.5 mm specimen, and eye diamet in head length has increased 1.3 per cent. Snout length in standar length has increased less than one per cent. Preopercular spine in hea length; tip of snout to tip of supraoccipital spine, and tip of snout t tip of preopercular spine in standard length all show decreases of 7. 4.8 and 12.5 per cent respectively. The opercular spine, however, ha increased in relative length, and several more serrated ridges have ap peared on the crown of the head. The bones ventral to the eye hav become noticeably serrated.

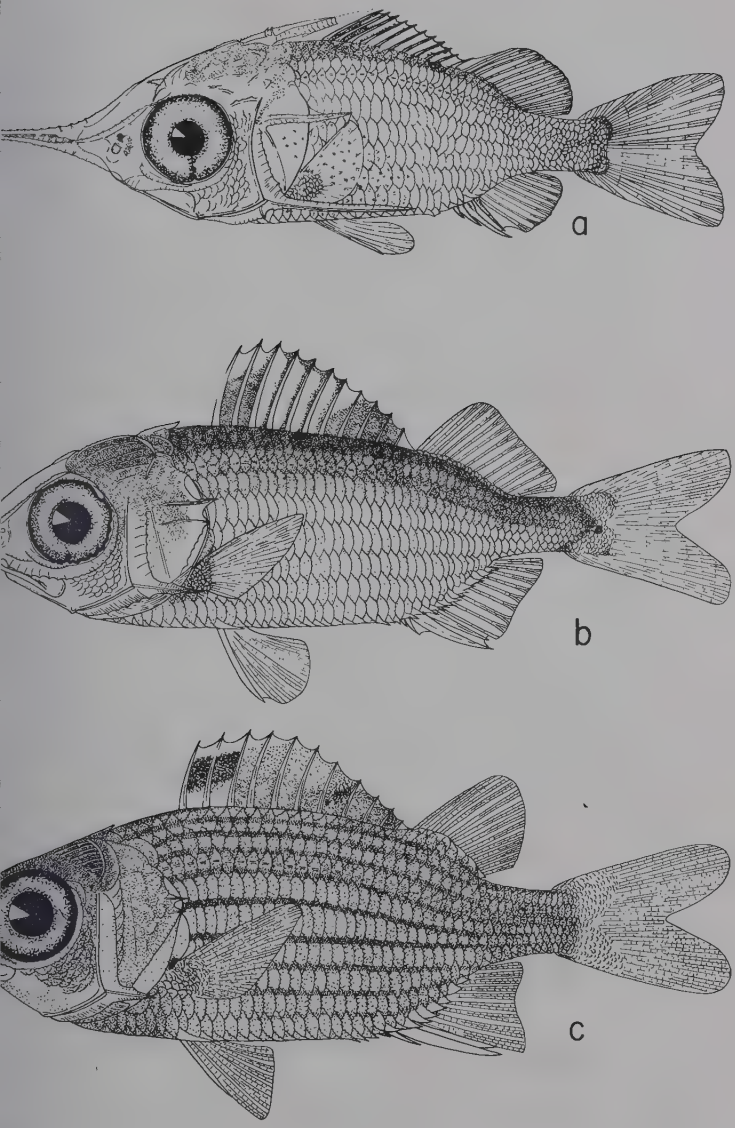


FIGURE 7. *Holocentrus vexillarius* Poey. a—15.9 mm., b—24.9 mm, c—32.5 mm.

The nares are clearly double and perforate. The unpaired fins, a
though possessing all of their elements, still differ in shape from tho
of the adult. The first dorsal fin is now higher anteriorly than posterior
in contrast to the smaller stages. The first and second dorsal are st
continuous, but there is a well-defined notch between them. The caud
fin is more deeply forked, but is considerably larger than it will be. Th
paired fins now have approximately the relative size and shape th
they will have in the adult.

Ctenoid scales now cover most of the body and lateral-line por
can be seen. The trend toward a dark pigmentation dorsally, whic
was noted in the preceding specimens, continues. The dorsal parts
the head and body above the lateral line, with the exceptions of th
snout and caudal peduncle, are quite heavily pigmented. There is son
pigment on the anterior part of the first dorsal and the chromatophor
on the visceral sac are still visible.

24.9 mm specimen (Figure 7b). Notable changes in the head spinatio
and the general body outline have occurred. Head length is now on
40.2 per cent of standard length due, at least in part, to the reductio
in the relative length of the rostral spine. The snout is 14.1 per cent
standard length, but is now deeper and has a more abrupt slope to i
dorsal profile. The supraoccipital spine and the preopercular spines a
also greatly reduced. The measurement from the tip of the snout to th
tip of the supraoccipital spine is only 41 per cent of standard lengt
and the similar measurement of the preopercular spine is 36.9 per ce
of standard length. The preopercular spine alone is only 27 per cent
head length. Due in part to the reduction of the relative length of th
rostral spine, eye diameter is 31 per cent of head length. Body dep
has increased to 30.1 per cent of standard length.

The opercular spine is still a prominent feature and a second ope
cular spine has appeared just ventral to it. This second spine, in a
dition, has an oblique row of serrations ventral to it. The serrate
ridges on the crown of the head are more prominent, as are the se
rations of the bones ventral to the eye.

The fins show little development over that exhibited by the 15
mm specimen. The caudal fin is still relatively large.

Pigmentation is still most apparent on the dorsal part of the anima
The anterior part of the head and the parts of the head below th
dorsal margin of the orbit are, in the main, colorless. A dark streak
pigmentation, which is brown in specimens preserved in formali
darker brown in specimens preserved in alcohol, and deep, steel bl

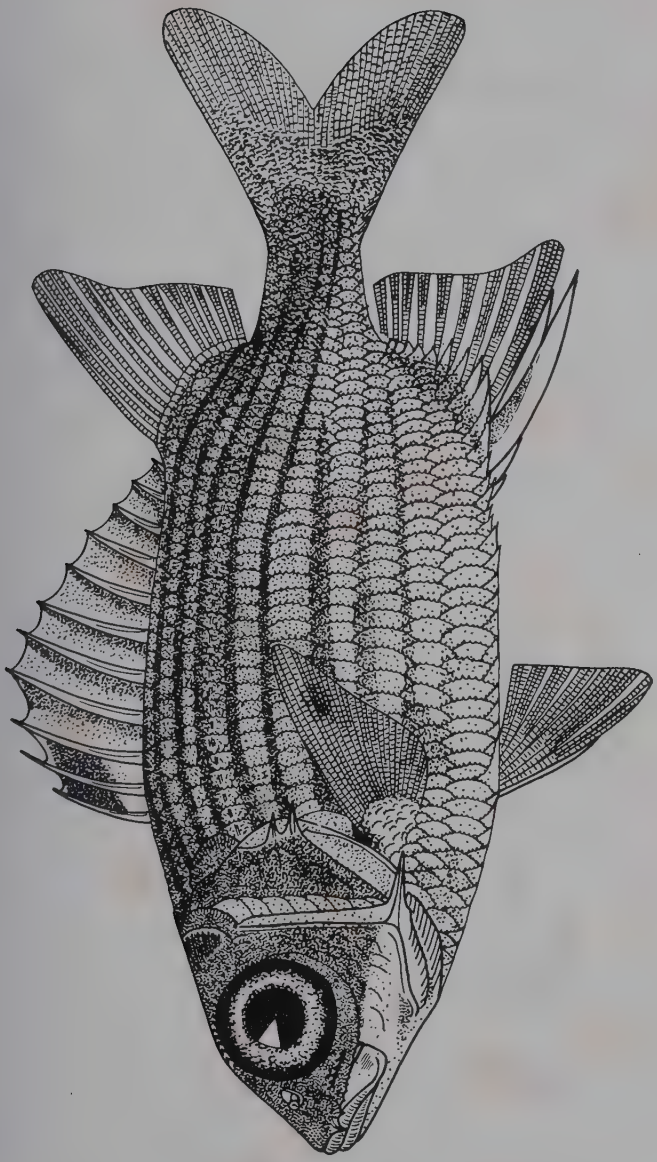


FIGURE 8. *Holocentrus vexillarius* Poey. 105.6 mm.

in live or fresh specimens, extends from above the eye almost to th caudal base where it ends in a point. Just below the middle of th caudal peduncle, at the base of the caudal, there is a small dark spot o pigment. The rest of the body, below the dark dorsal pigmentation an posterior to the head, is heavily punctate. In fresh and live specimens or specimens preserved in alcohol, this area appears silvery and th punctations are not as noticeable. The only pigment on the fins is tha on the first dorsal. The fin has a dark patch anteriorly and anothe posteriorly and between these there are streaks of pigment extendin along the spines. Fresh specimens sometimes show a light, diffuse, re coloration in the area of the body dorsal and posterior to the viscera Specimens preserved in formalin showed some of their myotomes an portions of the vertebral column outlined with brown. This is probabl an artifact, as it was not noted in fresh material examined, or in speci mens in alcohol.

32.5 mm and 105.6 mm specimens (Figures 7c and 8). The last tw specimens figured are essentially the same, although some difference are present. Head length is 37 per cent of standard length in the 32. mm specimen, and 35.5 per cent of standard length for the 105.6 mm specimen. Eye diameter in head length is slightly greater for the 32. mm specimen than for the 105.6 mm specimen, and considerabl greater than it was for the 24.9 mm animal. Preopercular spine lengt in comparison with head length is also greater in the 32.5 mm specime than in either the 24.9 mm or the 105.6 mm specimens. The rostra spine is completely absent and the supraoccipital spine is present onl as a ridge of bone. The bodies of both specimens are deeper than i earlier stages and the dorsal and ventral profiles are almost paralle along much of their length.

Over a size range of about 7 mm, striking changes have occurred i the coloration of the animal. Specimens larger than about 45 mm standard length have a general background color of silvery white wit flecks of orange or red. The intensity of the background color ma vary considerably. The part of the body above the lateral line and th dorsal parts of the head are the darkest. Some individuals are quite re while others are more brown or purple. There are three longitudina stripes of brown, black or purple above the lateral line. A shorter strip of a like color starts at the posterior part of the head and extends onl to the first dorsal. Below the lateral line there are five to seven shorte and more diffuse stripes. The first two or three of these may exten onto the caudal peduncle. The underparts are usually light colored, bu

ıy be quite dark, especially in the larger specimens.

The head is colored like the rest of the body, but has no stripes. ere is, however, a white streak from the mouth to the angle of the eopercle. The iris is a golden color flecked with some red and black.

The membranes between the first three dorsal spines are black ·dially. Posterior to this the membranes have a streak of black an- ior to each spine. These streaks often have a scarlet anterior border. e author has seen fresh material in formalin in which the entire color ttern of the first dorsal was scarlet. Specimens from the Florida Keys en were a deeper red than those from the Bahamas. The soft dorsal d anal usually have some red along the anterior rays. The caudal se is usually red and has streaks of red extending along its dorsal d ventral margins and out onto the caudal fin. The axils of the pec- al fins are black.

Inshore stages smaller than 45 mm are essentially the same in col- ıtion as those described above, but some differences are present. In ıeral, the longitudinal stripes are less distinct, especially those below lateral line. However, in some specimens, such as the one figured Figure 7c, all of the stripes may be as distinct as in larger specimens. th the exception of the first dorsal, the fins are usually colorless. The st dorsal has a black band medially between the first three spines, but sterior to this the pigment of the fin is more diffuse and not as con- ıtrated along the anterior border of the spines as it is in the larger ecimens. The black axils of the pectorals are generally not as distinct they are later, but all of the inshore specimens showed this character some degree.

Discussion

The most striking feature of the postlarval development of *Holo- ıtrus vexillarius* is the development and decline of four complex nes, (the rostral, supraoccipital and preopercular spines). From the pearance of the smallest specimen available (Figure 4a), it appears ıt the rostral spine, and probably the supraoccipital spine, are not esent at hatching. What the size at hatching is, and whether or not preopercular spines are present then, is not known. Figure 3a-e ows diagrammatic cross sections of these spines to indicate parts of eir structure not readily seen in the lateral views of the animals. Be- use of the rapid growth and development of the rostral spine, all of graphs concerning development (Figures 9, 10 and 11) are in- enced by including it in measurement of standard length and head

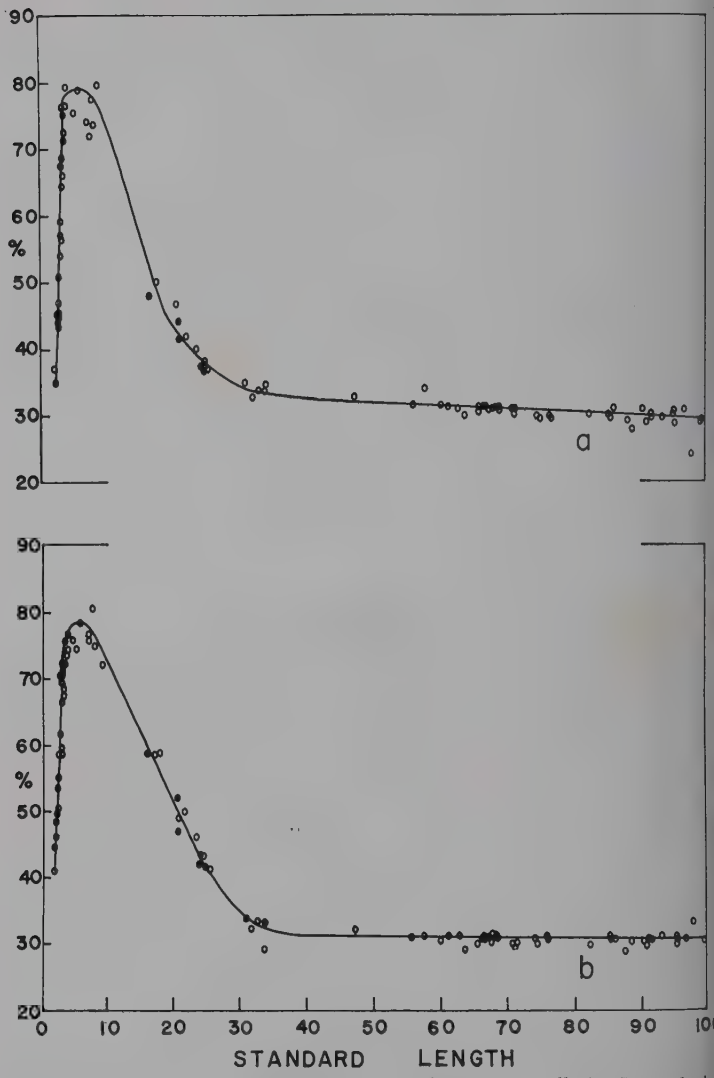
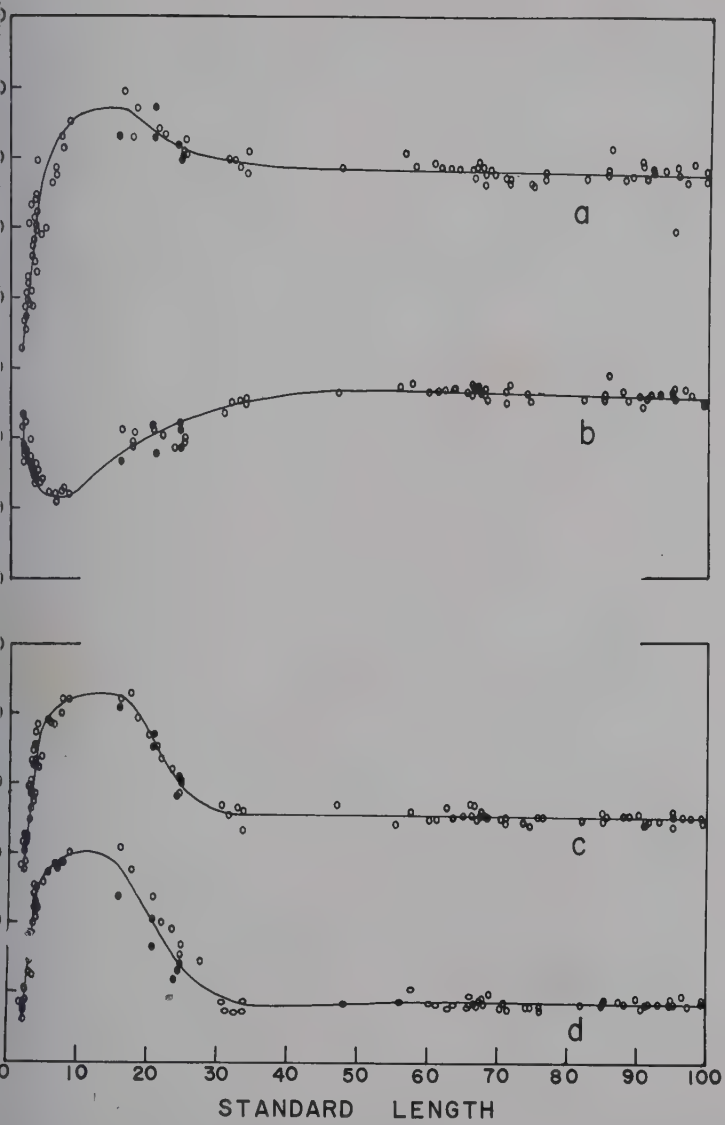


FIGURE 9. Change of body proportions in *Holocentrus vexillarius* Poey durin growth. a—Relationship of measurement from tip of snout to tip of supraoccip tal spine to standard length; b—Relationship of measurement from tip of snou to tip of preopercular spine to standard length.



URE 10. Change of body proportions in *Holocentrus vexillarius* Poey during vth. a—Relationship of preanal length to standard length; b—Relationship ody depth to standard length; c—Relationship of head length to standard th; d—Relationship of snout length to standard length.

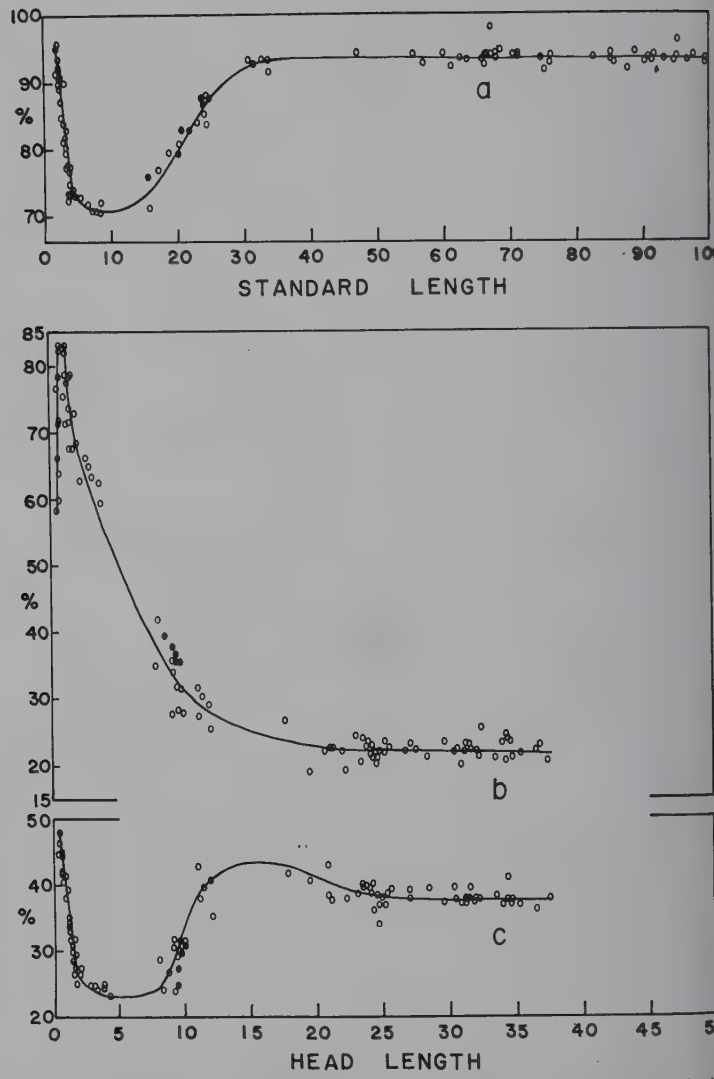


FIGURE 11. Change of body proportions in *Holocentrus vexillarius* Poey duri growth. a—Relationship of measurement from anterior margin of orbit to of the vertebral column to standard length; b—Relationship of preopercu spine length to head length; c—Relationship of eye diameter to head length.

ngth. The effect is to heighten and accentuate the peaks of the graphs, ore so in those involving head length (Figures 11b and 11c) than in ose involving standard length.

Figures 11a and 11b show that measurements from the tip of the out to the tip of the supraoccipital and preopercular spines respec-ely, exhibit a similar effect when related to standard length. The dices of these spine measurements reach a peak of about 80 per cent nen the animal is 6 to 8 mm in standard length. The development of e snout spine is indicated in Figure 10d where the snout index is otted against standard length. This graph has a flatter peak which arts at about 8 mm and begins to decline at about 15 mm standard ngth. A graph of the index of the preopercular spine in head length ainst head length shows a sharp peak at a head length of about 2.5 m which corresponds to a standard length of about 5 to 6 mm. It is ssible, therefore, that graphs 11a and 11b have been shifted slightly the right.

The rapid and extreme development of these spines in the postlarvae ses questions of their biological significance. It is difficult to ascertain e function of the spines without more detailed observations on living aterial representative of the various stages. Unfortunately the author s very few observations on living postlarval specimens and none of ese on the animal in its natural environment. Although the observa-ns were not suggestive, several hypotheses may be discussed.

They may serve as a floation device. Although these spines are of ne, their structure indicates a maximum of development with a nimum of material. The flat plates, which constitute the major ements of the spines, may support this idea. It should be noted that ines would not prevent the animal from sinking if it is more dense an the water in which it lives. Hardy (1956: 90) and others have scussed this for other animals in the plankton. Such an increase in rface area would probably tend to slow down vertical movements d permit the animal to combat sinking with less expenditure of ergy. However, in regard to a floating device, as Dr. Moore pointed t (personal communication), regaining lost depth would require ore energy than if the spines were not present. The spines are of aximum relative size during the animal's planktonic phase and de-ne rapidly as it becomes pelagic.

Another possible use of these spines is as a protective device. In the ages up to that represented by the 8.5 specimen, the preopercular ines are not held along the sides of the body, but protrude at an

angle. These spines in conjunction with the rostral and supraoccipita spines would give the animal a larger head size which might prevent being swallowed by some predators, although this would be no defens against predators which might seize it and tear it apart to eat it. Randa (1955) found that the second dorsal, second anal, and pelvic spine of the acronurus stage of the Surgeon Fish *Acanthurus triostegus sand vicensis* were poisonous. He has also informed the author (persona communication) that this ability to inflict a poisonous wound dis appears when the animals enter shallow water and transform to th juvenile stage. The situation in *Holocentrus* does not seem comparabl and it is inconceivable that the spines could afford protection agains larger predators as the dolphins *(Coryphaena)* and tunas *(Thunnus)* i whose stomachs many postlarval holocentrids are often found. Speci mens smaller than about 15 mm are seldom, if ever, recorded from th stomachs of other fishes, but this may result from failure of observer to recognize postlarval holocentrids. Possibly the spines serve n purpose.

Figure 10c shows the per cent of head length in standard length The graph is similar to the graph of snout length (Figure 10d). Th most rapid increase in length, up to a size of about 10 mm standar length, is in the snout. Figure 11a shows the per cent of a measuremer from the anterior part of the orbit to the end of the vertebral column or to the caudal base when it is formed, in standard length. The pa of the animal posterior to the snout does not increase in length as fa as the snout in the early stages. A small part of this difference probabl is due to the turning up of the end of the vertebral column and th forming of the urostyle. This is also indicated on Figure 10a wher the per cent of a measurement from the tip of the snout to the anus i standard length is shown. The section of the graph between 15 and 2 mm standard length indicates that a fairly rapid increase in lengt occurs posterior to the snout. Even though snout length is declinin at these sizes, the measurement from the tip of the snout to the anu does not decline as rapidly, nor reach as low a point as snout length.

Eye diameter in standard length, not shown on a graph, increase along with standard length. From the smallest to the largest specimer it remains at about 12 to 14 per cent of standard length. When con sidered mathematically in relation to head length (Figure 11c), ey diameter is more strongly influenced by the snout. In the smaller speci mens it is 48 per cent of head length, decreases to about 25 per cer in specimens 8 to 8.5 mm long, and then increases to about 43 pe

t in the 30 to 50 mm group. It is about 40 per cent of head length
ne larger specimens.

The mouth is terminal at hatching, but becomes inferior as the
ral spine develops, and remains so until the juvenile stage when it
gain terminal. It is always slightly oblique and is relatively large in
tlarval animals. Teeth were not seen in any of the postlarval speci-
ns, and are small in the adult.

Body depth in standard length decreases up to a size of about 8.5
and then gradually increases to about 35 per cent of standard
gth.

n the smaller specimens the only fins are the pectorals and the
dian fin fold. Pelvics appear when the animal is 5 to 6 mm long. At
stage the caudal base begins to develop and the first fin rays ap-
r. The last rays of the soft dorsal and anal fins appear at a size
ween 7.5 and 8.5 mm. These last rays frequently divide at the base
ost as soon as they appear.

Pigment appears first on the visceral sac and then on the ventral
t of the body posterior to the anus. Next, chromatophores appear
the crown of the head and the diffuse pigment on the visceral sac
ins to appear in chromatophores. Then pigment appears along the
erior part of the vertebral column, and at a size of about 8.5 mm
of the pigment, except that on the head, begins to be obscured by
developing body walls. At this time there is a tendency for pig-
ntation to be concentrated dorsal to the vertebral column, so that
ing the pelagic phase the animal has a dark blue-black, or brown,
k with silvery sides and underparts. This is a pattern common to
ny pelagic fishes. The only fin having any pigment during the pelagic
se is the first dorsal. In shallow water the pelagic colors are re-
ced by the complex pattern of the adult.

sible Variations in Development. Fowler (1944, p. 99) described
colors of six specimens of *Holocentrus vexillarius,* 37 to 46 mm
standard length, taken at Courtown Cays, off the east coast of
aragua. He figured one specimen (Figure 137, p. 238) which is
parently about 40 mm in standard length. According to his descrip-
n, these specimens had the color pattern of the pelagic young and
one he figured apparently had some remains of the rostral spine.
Anderson *et al.* (1956, 1957 and 1957a) also recorded specimens
H. vexillarius of more than 30 mm standard length which were
en by dip net in the Florida Current and in the Bahamas. Most of
se specimens, if not all, were taken in relatively deep water.

The largest pelagic specimen of *H. vexillarius* available to the auth is 24.9 mm in standard length and the smallest inshore specimen 30.5 mm in standard length. The author has no specimens larger tha 24.9 mm with either the color pattern or the rostral spine of the pelag stages.

Probably, some individuals remain pelagic for a longer period tha others, and retain some of the pelagic characters until moving in shallow water, or until movement into shallow water is possible. Po sibly some individuals grow faster than others under certain condition but remain at a similar stage of development until the pelagic life terminated. Also the author's specimens of about 30 mm standar length may be unusually small for inshore juveniles of this species.

Distribution

Most larvae were taken in a small area in and near the Florid Current. However, the SL station has been fairly regularly occupie for several years and the fish larvae sorted from all of the sample Other records are available in the literature. Thus, although materi available represents a limited geographical area, a general discussio is possible.

Geographical Distribution. Distribution records of *Holocentrus vexi larius* are shown in Figure 2. The chart represents published reference to *Holocentrus vexillarius* and its synonyms as given by Wood (1955), SL, Supl., and UMML material. Literature records include here are incomplete, and were omitted when locality data were n precise. Specimens examined by the author are designated as larval, as juvenile and adult on Figure 2, but literature records are not s designated.

The following records were found in the literature: Anderson an Gehringer (1957): *ca.* 26°25′N, 76°43′W; 30°00′N, 77°00′W 28°00′N, 78°00′W; and 30°19′N, 79°50′W. Anderson and Gehringe (1957a): 27°40′N, 79°18′W; 30°20′N, 79°26′W. Anderson, Gehri ger and Cohen (1956): 33°15′N, 76°23′W. Bean (1905): Abac Bahamas; and New Providence, Bahamas, as *H. siccifer*. Beeb (1936): Bermuda. Beebe and Tee-Van (1928): Port-au-Prince Ba Haiti. Both Longley (1941) and Woods (1955) believed Beebe's an Tee-Van's *H. coruscus* to be, at least in part, *H. vexillarius*. Brede (1927): Isle of Pines, Cuba; Swan Island and Glover Reef, Gulf Honduras. Cope (1871): New Providence, Bahamas, as the type *Holocentrum sicciferum*. Evermann and Marsh (1900): Ponce an

nica, Puerto Rico. Fowler (1944): Courtown Cays and Old Prov-ce Island, both east of Nicaragua. Gudger (1929): Loggerhead and Loggerhead Reef, the Dry Tortugas as *H. siccifer,* but he said elieved *H. vexillarius* was the same species. Howell-Rivero (1936): eside River in brackish water, one mile southeast of Port Antonio, aica. Lee (1889): Abaco, Bahamas, as *H. riparum.* Longley and ebrand (1941): The Dry Tortugas, Florida. Meek and Hilde-ıd (1923): Colon and Puerto Bello, Panama. Metzelaar (1919): acao and the "lake" of Bonaire, Netherlands Antilles. The author es with Woods (1955) that Metzelaar's figure and description of *coruscus* from Curacao is based on a small *H. vexillarius.* Paar 30): Rum Cay, West Caicos Island, Turks Island, and Crooked ıd, Bahamas. Poey (1860): Cuba, probably near Havana, as the of *Holocentrum vexillarium.* Poey (1865): Cuba as the type of *ocentrus brachypterus.* Poey (1875): Cuba as the type of *Holo-rum riparum.* Springer and Bullis (1957): Arcas Cay, Gulf of ıpeche and 28°42′N, 88°48′W.

Unpublished records of specimens for which data are not given elsewhere in this study include the following from the Marine Laboratory's ections: UMML 1374 (1957): West end of Bahia de Yegua, rto Rico. UMML 1396 (1951): Nicholstown, Andros Island, amas. UMML 1711 (1957): South side of Pigeon Cays, 11 miles heast of Andros Island, Bahamas. UMML 2136 (1957): Bay side Long Key, Monroe County, Florida. UMML 2408 (1958): Alli-or Reef, about 6 miles east of Lower Matecumbe Key, Florida. ot indicated on Figure 2.)

These records show a fairly wide distribution in the Gulf of Mexico, Caribbean Sea, and northward into the Florida area and the north-Bahamas. The species is present in and around Bermuda.

Although there are several records for the Dry Tortugas in the rature, none were found for the Florida Keys proper. During the t year, extensive shore collections have been made in the Keys by oins in conjunction with a study of the fishes of the area, and a few cimens of *H. vexillarius* (one from Long Key and five from Sum-rland Key) have been taken. None of the poison stations in the s have revealed the species in the numbers comparable to similar ions in the Bahamas and Puerto Rico. The reasons for this are not wn, but it may be due to some factors encountered during the gic phase, when distribution occurs. It would seem doubtful that eniles and adults travel any great distance once they are established

in shallow water. Robins has suggested (personal communicatic that water clarity may be a factor. Inshore waters in the Keys are of somewhat turbid, but the two places where *H. vexillarius* were tak had clear water comparable to Bahaman and Puerto Rican station

Walter R. Courtenay (personal communication) has often encot tered *H. vexillarius* at Key Largo Dry Rocks, a coral formation thi or four miles offshore on the west side of the Florida Current. I informed the author that it is the holocentrid most often seen the This area also has clear water and usually remains so except unc conditions of prolonged wave action. This is also true of Alligat Reef where UMML 2408 was taken. Al Pfleuger (personal commu cation) stated that the holocentrid most often taken by hook and li fishing in Florida seemed, in his experience, to be *H. ascensionis*.

There are numerous records of holocentrids north of what is usua considered their normal range. Jordan and Gilbert (1882) referred a record of *H. pentacanthus* from Newport, Rhode Island. Sumn Osborn and Cole (1911) referred to several records of holocentri from the Woods Hole area. They believed most to be *H. ascension* Fowler (1935) reported on a specimen found washed up on the bea at Atlantic City, New Jersey. The colors he described are those of pelagic specimen and his figure has counts more indicative of *H. coru cus* or *H. bullisi* than of *H. vexillarius*, which was his identificatio Anderson *et al.* (1956, 1957 and 1957a) reported specimens of *H vexillarius* from dip net collections as far north as the Carolinas at st tions in the Gulf Stream. The ALBATROSS specimen was from a stati well north of Bermuda. The presence of *H. vexillarius* in Bermuda, reported by Bean (1906) and Beebe (1936), is not unusual when o considers that Bermuda has a waif fauna; many West Indian mari animals are present there.

Usually, northern records are of pelagic forms taken by dip nets similar equipment. No record of an established colony of *H. vex larius* is known north of the northern Bahamas, except for Bermud

Records of tropical organisms taken far outside their normal ran are not unusual. Hardy (1956, p. 20) and others have listed anima and plants, usually seeds, found on the coasts of the British Isl which must have originated in the warm seas of the Western Atlan or on its shores, and were carried across by the Gulf Stream.

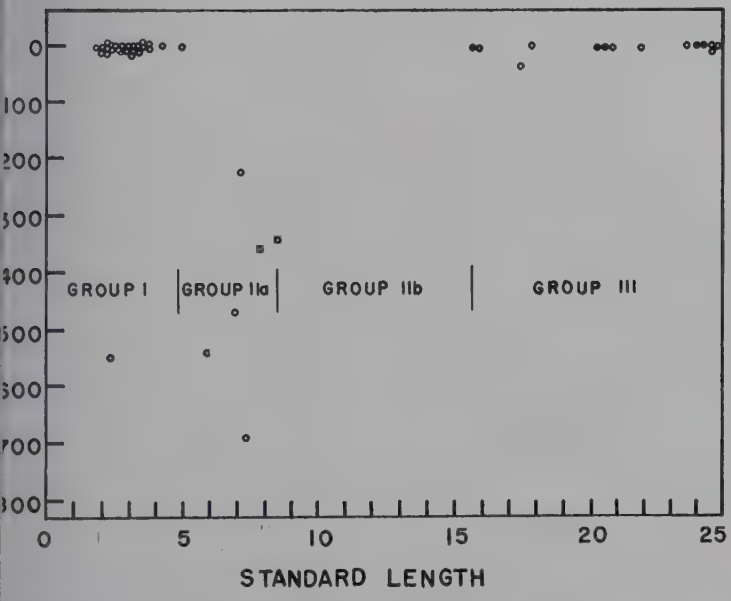
Vertical distribution. Vertical distribution is best discussed by si groups. The specimens can be arranged in five groups as listed belo

Group I—1.8 to 5.0 mm standard length.

roup IIa—5.8 to 8.5 mm standard length.
roup IIb—8.6 to 15.7 mm standard length.
roup III—15.8 to 24.9 mm standard length.
roup IV—30.5 to 107.7 mm standard length.

e five groups, although convenient for a discussion of vertical ibution, do not coincide with developmental stages. Figure 12 s the relationship of standard length to depth of capture.

ll Group I larvae were captured at the surface with the exception of 2.3 mm specimen. The majority (74 per cent) were taken in Supl. s along the northwestern edge of the Great Bahama Bank. The ining larvae in this group were taken at the surface of the deeper rs of the Florida Current. No Supl. hauls were made more than w feet below the surface, but both SL and Supl. hauls took larvae is group at the surface during darkness and daylight. No speci- s were taken during the brightest hours of the day, although the station was occupied during those hours. There is a tendency for



URE 12. Relationship of depth of capture of standard length of larval specimens of *Holocentrus vexillarius* Poey.

the larger larvae in this group to have been taken over deeper wat

All larvae of Group IIa were taken at the SL station at dep ranging from 228 meters to 687 meters. All specimens were tak during hours of darkness or dusk. Observations on a specimen 7.3 m long, after having come up from a considerable depth in a plankt tow, revealed that it could swim better than the copepods in the j but not as well as the larger decapod crustaceans and chaetognaths.

Group IIb is absent in this series.

Group III larvae were, with one exception, taken by towed nets dip nets at night. All were at, or close to, the surface. One specim 15.8 mm long, was taken in a standard SL haul. Two specimens 17.5 mm and 17.9 mm were taken in a two-meter diameter net tow at about three knots; one at the surface and one at about 35 met depth. The rest of this group were all captured by dip net and ligh Observations of specimens of this group by the writer, both under t night light and in a bucket on deck immediately after capture, vealed that they were capable swimmers.

The specimens in Group IV were captured by poisoning in wa less than one meter to about three meters deep. There is a gap betwe this group and the last of about 5 mm of standard length. Specime in this group between 30.0 mm and 50.0 mm were not as common larger specimens.

In summary, the following pattern of vertical distribution is su gested by the material examined. Larvae of about 2 mm to 5 mm we usually found close to shallow waters. They were probably spawn in the shallow waters and carried into the deeper waters of the Flori Current by water movements. In the deeper water they were found depths between 200 and 700 meters after they had attained a size more than 5 mm. Here development progressed toward a pelagic w of life.

Between a size of about 9 mm and 15 mm, the larvae became a to avoid capture in a plankton net, and were not taken in dip nets towed nets. The last two methods of sampling were carried out irregularly that they cannot be considered adequate.

Larvae of 15.8 mm and larger were common in dip net and tow net collections made at night at the surface. Daytime sampling these methods was inadequate to indicate the depth at which th were living during these hours.

Since juveniles and adults are well distributed in the Gulf of Mexi

Caribbean Sea, and the Bahamas, some are probably farther from
water, such as that of the Florida Current, than my specimens.
nall number of plankton samples from limited shallow water areas
ne Great Bahama Bank have been examined by the writer, but no
centrid larvae were found. However, these samples are few in
ber and from a limited region. At Pigeon Rocks, where the author
rved some juveniles and adults, there was a strong tidal current
h would presumably have swept eggs or small larvae into deeper
er eventually. The limit in depth to which the juveniles and adults
nally live is not known. All records are apparently from waters
h less than 100 meters deep.

Spawning

tudies on the early life history of some species of fish found in the
ida Current have indicated spawning periods several months long
in some cases, nearly all year (N. Voss, 1954; Legaspi, 1956;
Clancey, 1956).

pecimens of *Holocentrus vexillarius* 8.5 mm in standard length
less were taken in all months except January, February, and No-
ber. All but three of the larvae were taken from March to Septem-
inclusive. Since weather is more likely to restrict collecting opera-
s in the fall and winter, the scarcity of specimens from October
ebruary is probably due to inadequate sampling.

ive specimens from Turtle Rocks, Bahamas, had ovaries in stages
o IV of the gonad maturity scale established by the International
ncil (International Councils Rapports et Proces-Verbaux des
nions, March 1931, p. 117). The eggs were irregular in shape,
que, and about 0.3 mm in diameter.

Food and Feeding

able 4 shows the results of a stomach examination of 62 speci-
s of *Holocentrus vexillarius*. All specimens less than 30 mm long,
pt those from the National Museum, were dissected and the con-
s of the stomachs noted. The stomachs of 21 of the specimens
er than 30 mm were also examined. Only those specimens with
ething in their stomachs are listed on Table 4.

f the 41 specimens smaller than 30 mm, only nine had recogniz-
food in their guts. The smallest specimen, 1.8 mm long, and one
mm long, were still carrying small amounts of yolk. No other food
detected in the guts of these specimens. No yolk was found in
ther specimen 2.1 mm long.

TABLE 4

STOMACH CONTENTS OF SPECIMENS OF *Holocentrus vexillarius* POEY CONTAINING IDENTIFIABLE REMAINS.

Standard Length	Stomach Contents
1.8	some yolk
2.1	some yolk
3.0	1 copepod leg
3.4	1 pelycopod veliger
3.6	2 gastropod veligers
3.7	1 pelycopod veliger
3.8	1 pelycopod veliger
23.5	1 calanoid copepod
24.5	1 mysid
30.5	1 copepod
47.0	1 pelycopod
57.2	2 crab chelipeds
	1 chiton
	1 foramenifera
66.3	barnacle legs
	2 brittle star arms
68.5	1 brittle star arm
70.8	1 isopod
71.0	1 isopod
	various crustacean limbs
	(mostly isopod and barnacle)
76.0	2 isopods
	2 crab chelipeds
	1 octopus arm
85.5	1 limpet *(Diodora)*
	4 ostracods
	barnacle and crab limbs
87.6	1 small crab
91.3	crustacean appendages
	1 brittle star arm
93.0	1 octopus beak
	4 ostracods
	barnacle-tergum
	4 alpheid chelipeds
	1 eye (octopus)
95.0	1 harpactacoid copepod
97.5	barnacle tergum
	2 alpheid chelipeds
99.5	various crustacean limbs
99.8	4 isopods
	1 limpet
	2 alpheid chelipeds
	1 small octopus
104.0	1 ostracod
	barnacle limbs

n other specimens the food was all of planktonic nature. Molluscan gers were present in four, and crustacean remains in three others. nough veligers were identified in only four animals, these were quite ely spaced in time, which may indicate that veligers constitute at t part of the diet of specimens 3 to 4 mm long. The four specimens cerned were taken in June and December of 1953 and in May and ober of 1956. Various workers, including Lebour (1919), Voss 54), and Legaspi (1956), have indicated that some larval fishes v preferences for certain organisms, or groups of organisms, al-igh Lebour (1918 and 1919) also showed that they will change r diet if necessary.

Many specimens below 30 mm seemed to have striated muscle fibers heir guts. These specimens may have eaten soft bodied animals left no hard parts. Although care was taken not to damage the imens unduly, these fibers may have been part of the specimens nselves. Under these circumstances, the writer felt obliged to re-l them as empty and has not listed them on Table 4.

The inshore specimens, with the exception of one 30.5 mm specimen taining the remains of what was probably a calanoid copepod, all wed indications of being bottom feeders. They had eaten a variety nimals including mollusks, brittle stars, ostracods, harpactacoid epods, barnacles, and decapod crustaceans. All food was of a size esponding with the moderate mouth size of this species.

Often the remains indicated that only parts of animals had been n. Brittle star arms were found, but no disks, barnacle appendages some terga, but no wall plates, and decapod appendages, but om any other parts of the crustacean. Other invertebrates were n whole. This group included isopods, ostracods, limpets, chitons, octopus. The cephalopod beaks and eyes indicated that these nals were eaten whole, and that the cephalopods were almost cer-ly octopus. One specimen did have a partially digested octopus in guts, but one other had only an arm. Comparison of the beaks and s found with specimens of octopus in the Marine Laboratory col-ions led the writer to believe that they were from small specimens, bably about an inch across the arms.

During this study the writer observed some individuals of this cies in an aquarium. Only once was a specimen seen to feed. Some ces of shrimp were put into the tank and one individual darted to-d a small piece and seized it in mid-water and then spat it out. The vements were similar to those described by Meader (1939) for the

aquarium feeding of *H. ascensionis*. However, this type of feedin does not correspond well with the habits of the animals found to mak up the diet of *H. vexillarius*. Most of the animals making up the ston ach contents are bottom dwellers of either a crawling or a sessi nature, and the fish would seldom come upon them in mid-water.

Habits

Behavior. Observations on living holocentrids in their natural su roundings have usually been made during the day. The fishes are cor sidered to be nocturnal, but are not entirely inactive during daylig hours. They are usually found in rocky areas or in coral formatio (Jordan and Thompson, 1905; and Longley and Hildebrand, 1941

While collecting fishes from rock pools in cay rock formations Rabbit Keys near Bimini, Robins (personal communication) recorde habits of *Holocentrus vexillarius*. The rock pools are often only one two feet in depth and in communication with the sea at high tid There are usually many holes in the sides and bottoms which ramif far into the surrounding rock.

Only a few individuals were usually seen in such pools, back in th shadow of some overhanging ledge or rock. The population howeve was often large and was disturbed by the introduction of poiso Thirteen were seen to leave one such pool, but they returned an hou or so later, at which time the pool was disconnected from the ocea All thirteen hopped the six-inch barrier and reentered the pool whe they were immediately captured.

Such observations strengthen the reports that these fishes remai hidden during the day unless disturbed. Also, a strong preference fo a specific home range is indicated. Such a habit might tend to lim the numbers of this species in a given area depending on the numb and size of suitable holes.

Jordan and Thompson (1905) and Longley and Hildebrand (194 referred to the retiring habit of *H. vexillarius* during the day. Longle and Hildebrand (1941) also reported that an individual of *H. asce sionis* used the same hole every day for a month.

During a trip to the Bahamas in early December of 1957, the writ observed some holocentrids at a small island called Pigeon Cay, sout east of Andros Island. Although of typical cay rock construction wi undercut edges full of holes of various sizes, no holocentrids we seen living in the area immediately adjacent to the shore. Howeve several feet seaward, below low water, there was a growth of cor

ch consisted of both coral heads and pieces of cay rock encrusted
n coral. Further out, in about three meters of water, there was a
tch of sandy bottom and beyond this, in still deeper water, another
al area. A strong current ran past the cay on both incoming and
going tides.

The area examined most thoroughly was the coral growth several
from shore where the depth was only one or two meters. Although
ilar to other cays in the area, several animals were noticeably ab-
t. Among these were representatives of the genera *Astrea, Conus,*
prea, Trivia, and *Octopus* and some of the tube polycheates. Of
holocentrids, *Plectrypops retrospinus* (Guichenot, 1853), *Holo-*
trus ascensionis (Osbeck, 1771), *H. rufus* (Walbaum, 1792), *H.*
uscus Poey, 1860, and *H. vexillarius* were seen and collected.

Occasionally holocentrids, usually *H. ascensionis* or *H. rufus,* would
m about in the open, but when disturbed they would dart into a
e. For the most part, each individual holocentrid appeared to have
own hole. This was particularly true of the larger individuals, but
ne of the larger holes were occupied by more than one individual
sometimes by more than one species. Attempts to drive a holo-
trid from a hole usually resulted in the fish simply moving to the
of the hole farthest from the disturbance. None could be driven
the open except by the most drastic measures such as prodding
h a spear or introducing poison into the area.

On several occasions the author observed other fishes being driven
m a holocentrid hole by its occupant. A sudden dart, a common
vement of holocentrids, with the dorsal and anal fins extended,
uld suffice. On other occasions small fishes would casually enter
h a hole and there would be no effort to drive them away.

Differences in the behavior of the species of holocentrids present
re not noted during the short time that they were observed.

Dr. John E. Randall told the author that he has observed *H. vexil-*
ius far under the overhang of cay rock in a similar area. At the
ne of his observation there was a strong surge present. Longley and
debrand (1941) also noted that a strong surge would cause these
mals to come from their holes.

Salinity preference. With the exception of one adult specimen report-
by Howell-Rivero (1936) from brackish water in Jamaica, all
ords of *H. vexillarius* are from marine waters. In areas such as rock
ols, salinity may be lowered by rain or increased by evaporation, but
ce there is often a constant supply of sea water coming in through

the porous cay rock this probably never becomes a restrictive facto

Temperature preference. This species does not live where shallo water temperatures drop much below 20°C. even though post-larv stages encounter temperatures well below this. The temperatures r corded with Group IIa specimens (see section on vertical distributio ranged from 19.5°C. to below 10°C. and if Group III migrates diur ally it must also encounter temperatures below those encountered b shallow water specimens. Adult specimens taken at Summerland Ke Florida were in water warmer than 32°C. and such temperatures a not uncommon in similar shallow water areas in the range of th species.

Illumination preference. Since adults are nocturnal, the speci probably prefers low illumination. However, Group I specimens mu have encountered high illumination at the surface during the day, contrast to the deeper living specimens in Group IIa. Group III spec mens taken by the author were attracted to the night light.

Enemies. The larvae of *H. vexillarius* are probably eaten by coele terates and ctenophores, since Lebour (1922) showed that these ar mals consume many larvae and some eggs. Lebour (1923) al observed chaetognaths eating fish larvae and it is possible that your holocentrids are eaten by them, but it would seem that the spin would make it difficult for the holocentrid larvae to be swallowe Other possible predators would include small fishes and some crust ceans. Beebe (1936) recorded 392 specimens of *H. vexillarius* fro the stomachs of ten specimens of *Parathunnus atlanticus* (= *Thunn atlanticus*), but he did not say whether the 392 specimens were pos larval, juvenile, or adult. The author has seen numerous unidentifie postlarval holocentrids from the stomachs of dolphins (*Coryphaen* and tuna (*Thunnus*).

Use As Food

The author can find no definite evidence of *H. vexillarius* bei eaten by man. *H. ascensionis* and *H. rufus* are eaten. Vincent (191 said that *H. ascensionis* and *H. marianus* are eaten in Trinidad, b are not considered very good. Local Floridians who had eaten Squirr Fish told the author that it was very good, but that the spines ma them difficult to handle, so they were seldom used as food. A rece survey by Camber (1955) listed Squirrel Fish under the species ma keted as Red Snapper.

Dr. Randall told the author that Squirrel Fish, especially the larg

cies of *Myripristis,* are considered a great delicacy in parts of the cific and bring a high price on the market.

Summary

1. The materials and methods of collection and study of the larval, enile, and adult specimens of *Holocentrus vexillarius* Poey from Gulf of Mexico, the Florida Current, the Western Atlantic, Flor-, and the Bahamas are summarized. Characters of use in separating larvae of *Holocentrus vexillarius* from other holocentrid larvae the supraoccipital spine pattern, pigmentation, body proportions, l, upon their appearance, fin elements and scales.

2. Previous references to postlarval holocentrids are given.

3. A developmental series consisting of two prolarvae, 45 post-vae, five juveniles, and 45 adults, ranging in size from 1.8 mm to 7.7 mm in standard length is described and discussed. Figures of rteen specimens are provided.

4. Indices and graphs of gross morphological changes occurring ring development are presented. The larval peak is strongly marked e to the rostral spine of the postlarvae. The larvae are "planktonic" il they are about 9 mm long and then become "pelagic." There is netamorphosis involving head spination and color pattern which curred at a size of about 25 mm to 30 mm in this series. Possible iations in this development pattern are briefly discussed.

5. The geographical distribution of the material studies plus records m the literature are presented. The known range of *H. vexillarius* ludes the Gulf of Mexico, the Caribbean Sea, the Bahamas, Flor-, and Bermuda. Northern records of this species are discussed. The tical distribution of larvae indicates that a size and depth pattern is sent.

6. The occurrence of the larval material studied indicates a long n spawning in the Bahaman area with planktonic and pelagic ises in the Florida Current.

7. Results of examination of stomachs of 41 larvae and 21 juveniles l adults are presented and discussed. The larval diet includes plank-ic crustaceans and molluscan veligers. The juvenile and adult diet ludes a wide variety of bottom invertebrates.

8. Habitat, behavior, relationship to salinity, temperature, illumina-n, enemies, and use as food by man are discussed. *Holocentrus illarius* is a nocturnal animal and there is good reason to believe

that individuals have a preferred home range, usually a hole or cra in a rock or coral formation.

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FLORIDA STRAITS TRANSPORTS: JUNE 1956 - JULY 1958[1]

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The data presented here are continuations of those presented in earlier number of this journal (Vol 7, No. 3, pp. 252-254), and a subject to the same explanations, qualifications, and are in the sa units. The chief point of interest is the rather high set of numbers June and July of 1958. As explained in the earlier report, there m be something specious about the interpretation of these measured v tages in terms of transport so that I hope these numbers will be a cepted with caution by other investigators.

TABLE 1

24-HOUR AVERAGES OF FLORIDA STRAITS TRANSPORTS IN MILLIONS OF CUBIC METERS PER SECOND.

1956					
June	10	25.6		23	32.8
	24	(26.4)		29	30.2
		very noisy		30	29.0
	30	23.2	Oct.	6	28.8
July	1	22.9		7	28.9
	7	22.4		13	20.0
	8	21.4		14	18.6
	14	23.4		20	22.5
	15	23.4		21	24.3
	21	23.0		27	20.5
	28	23.7		26*	23.7
	29	24.2		27*	21.3
Aug.	4	25.0	Nov.	3	19.6
	5	24.8		4	17.5
	11	24.9		11	21.3
	12	26.5		17	29.7
	18	24.4		18	31.2
	19	23.7		24	25.0
	25	20.8		25	26.4
	26	21.5	Dec.	2	24.3
Sept.	1	24.5		9	26.6
	2	22.9		15	32.3
	9	26.5		16	32.1
	15	25.6		22	28.1
	22	32.1		23	28.8
				29	27.6
				30	26.6

[1]Contribution No. 1008 of the Woods Hole Oceanographic Institution. This work was d under contract with the Office of Naval Research: N6onr-27701.

TABLE 1 (Continued)

1957		
Jan.	5	30.6
	6	32.0
	12	29.5
	13	28.3
	19	22.3
	20	22.1
	26	23.9
	27	23.8
Feb.	2	22.6
	3	21.4
	9	21.5
	10	21.5
	16	21.9
	17	20.6
	24	23.1
Mar.	3	29.8
	9	27.3
	15	25.6
	16	25.7
	22	24.0
	23	24.5
Apr.	14	23.9
	20	20.9
	21	21.3
June	1	27.0
	2	28.5
	8	29.6
	9	30.4
	15	32.4
	16	33.7
	22	30.4
	23	30.0
	29	29.2
July	13	24.7
	20	31.4
	27	31.8
Aug.	3	26.8
	10	22.4
	17	24.9
Aug.	24	20.9
	31	30.3
Sept.	7	34.1
	21	26.1
Oct.	12	24.6
	19	21.8
	26	24.6
Nov.	2	21.1
	23	26.3
	30	23.9
Dec.	7	19.3
	14	20.2
	28	30.8
1958		
Feb.	16	28.9
Mar.	2	29.7
	8	27.2
Apr.	5	29.6
	6	28.6
June	1	35.5
	8	33.3
	14	38.1
	15	38.2
	21	38.2
	22	38.9
	29	43.0
July	5	41.2
	6	42.6
	19	49.6
	20	54.2

SOME NOTES ON TIDES IN ANNABAAI HARBOUR, CURACAO, NETHERLANDS ANTILLES[1]

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ABSTRACT

On the basis of the available tide gauge records over the period 1950-1956 the character of the tides in Annabaai Harbour, Curaçao, was determined. A periodic change of a diurnal and semidiurnal period, comprising 13.7 days, was observed. The average daily range between the tides in the period mentioned proved to be 29.7 cm. In relation to the currently accepted datum level, the so-called "Curaçaos Peil" (C.P.), it became obvious from the available data that the "true" mean tide level was situated 6.35 cm above C.P. A semi-annual variation in the height of the average sea level was observed; low sea level occurs during the first half of the year, and high sea level during the second half. The average percentage of submergence of different zones in the tidal region was determined.

INTRODUCTION

Very little is known about tidal movements in the Netherlands An tilles. Although recordings of tide gauges in the islands of Curaça and Aruba exist, the data have not been tabulated up to this dat The following is an attempt to interpret the information contained i a series of tide gauge recordings taken in Annabaai Harbour, Curaça during the period January 1950 to January 1957.

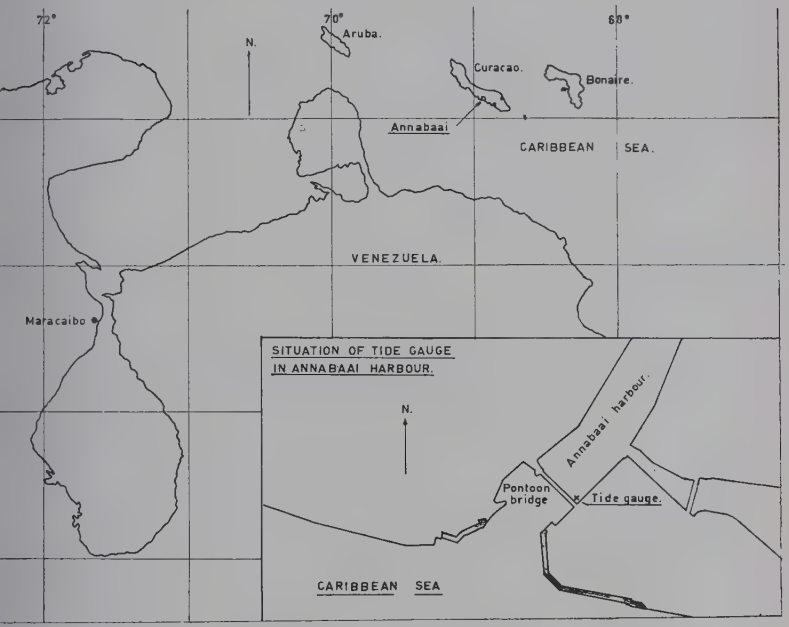
DISCUSSION

Data. A float-type sea level gauge is situated near the entrance t Annabaai Harbour. Recordings of the float movements are obtaine by transmission of signals to an automatic recording device in th Harbourmaster's Office. Recordings are controlled by comparisc with a fixed direct reading scale. The available graphs show tid movements in 1,788 complete 24-hour periods from the years 195 to and including 1956.

The position of the tide gauge relative to the harbour entrance an a small scale orientation map are given in Figure 1.

The general type of tidal movements. The normal tidal rhythm to be seen in Figure 2. From these lines it is obvious that the tid movements in this part of the Caribbean Sea are subject to the wel known periodic changes. On some days only one high tide and on

[1]Contribution No. 15 from the Caribbean Marine Biological Institute, Curaçao, N. A.



URE 1. Orientation map showing the position of the tide gauge in Annabaai bour. Scale of map 1:1, 650,000; scale of inset 1:10,000. The exact position he gauge is 12° 6.3′ N, 68° 56.3′ W.

tide occur in approximately 24 hours and 50 minutes (one lunar), while on other days the tide becomes semidiurnal. The two es alternate regularly as may be seen in Figure 3, where high tide l low tides are plotted against time for a larger number of days. Figure 3 the data of the observations during 70 consecutive days given. As is always the case in localities where semidiurnal s appear, spring and neap tides each occur in fortnightly periods. The number of intervals between one spring tide and the next was ermined between Jan. 10, 1954 and Nov. 9, 1955. Forty-nine rvals occurred in 668 days; hence the average length of one inter- during that period is 13.7 days.

No explanation has been found for this deviation from the normal iod of 14.7 days.

e range of the tides. To determine the average range of tide the ximum and minimum levels for each day of the period between

January 1, 1950 to December 31, 1956 were taken from the recor
ing graphs.

The difference between the highest and the lowest sea level in eac
24-hour period was taken as "daily tidal range." These daily tid
ranges were grouped in 5 cm intervals (Table 1) and then a fr
quency diagram was constructed (Figure 4).

It follows from Table 1 that the average daily tidal range durir

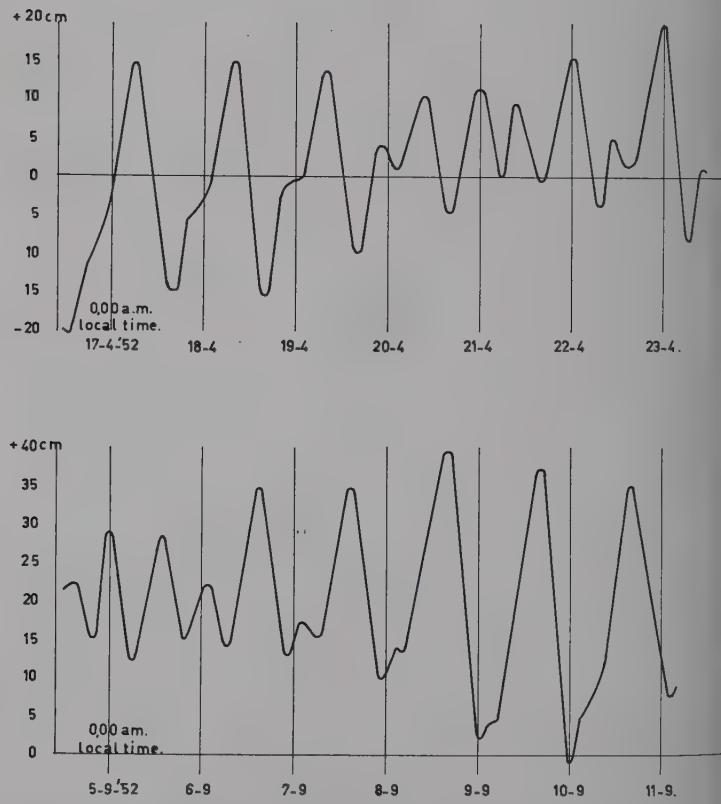


FIGURE 2. Tidal movements at the entrance of Annabaai Harbour in the p
riods April 17-23, 1952 and September 5-11, 1952. Levels are referred t
"Curaçaos Peil" as datum level.

TABLE 1

FREQUENCIES OF DAILY TIDAL RANGES OVER THE PERIOD 1950-1956.

	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	—	—	4	—	1	—	—	3	4	—	1	—	13
	4	13	14	6	4	—	—	5	10	9	4	2	71
	19	18	18	23	17	11	21	25	25	26	16	13	232
	10	14	25	24	22	24	25	35	23	24	15	16	257
	18	24	28	27	25	19	26	32	51	32	17	20	319
	22	22	34	35	22	28	25	36	38	44	30	17	353
	17	14	19	22	34	23	34	32	29	25	35	21	305
	11	3	2	14	12	22	17	12	3	15	24	14	149
	5	4	—	4	14	17	10	4	—	1	10	8	77
	1	—	—	—	3	4	—	—	—	—	2	2	12
l													
th	107	112	144	155	154	148	158	184	183	176	154	113	1788
on.			518			644				626			
i													

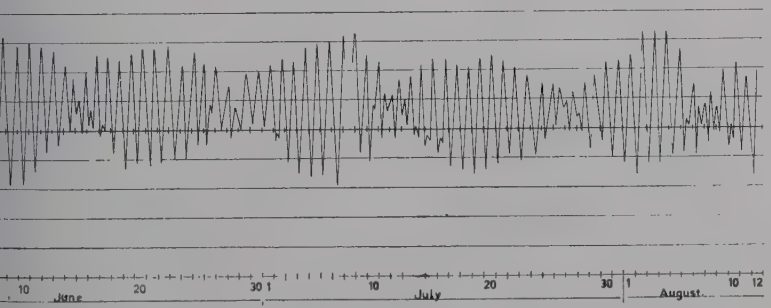
period under consideration is 29.7 cm; the standard deviation ne daily tidal range is 10.7 cm.

The averages for the data from the 4-months' periods Jan.-April 8 days), May-August (644 days) and Sept.-Dec. (626 days) e calculated from the data of Table 1 and found to be 27.6 cm, 3 cm and 29.8 cm respectively.

Now if no real difference between these periods exists the stand-

error for the averages of the periods can be calculated as $\frac{\sigma}{\sqrt{\eta}}$

re σ is the standard deviation of the frequency of distribution of



URE 3. Tidal movements over a period of 70 days in Annabaai Harbour. Levels refer to "Curaçaos Peil" as datum level.

all daily tidal ranges and η is the number of data in each period; th gives 0.47 cm and 0.42 cm respectively for the periods Jan.-Ap and May-Aug. The actual differences between these period averag and the total average are about 4 times the standard errors and m be considered significant; the difference is very small (0.1) for t period September-December.

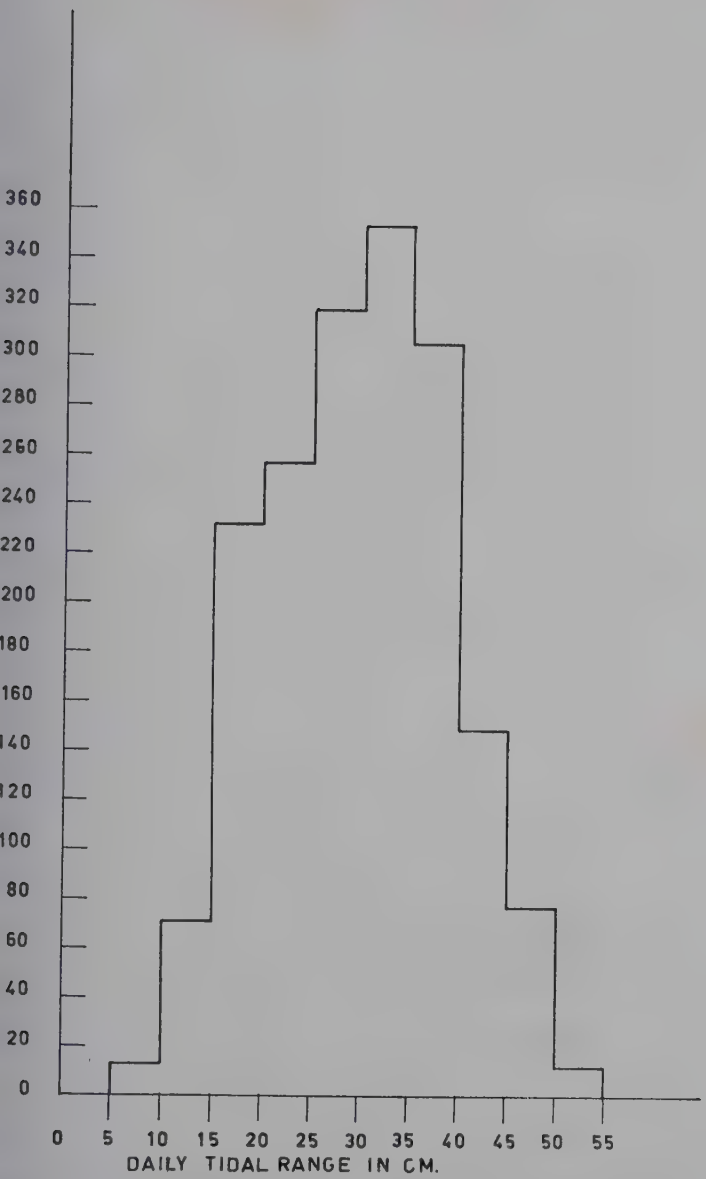
Mean tide level. Up till now sea water level in Curaçao is alwa given in relation to a datum level, called "Curaçaos Peil" (C.P. There are no reliable data as to the way in which this datum lev was determined. Unless stated otherwise, this "Curaçaos Peil" taken as the starting point for the following considerations.

Daily mean tide levels over the period January 1950 to Decemb 1956 are calculated as averages of the highest and lowest levels 24-hour periods. These "daily mean" values were grouped in 2 c intervals (Table 2) and a frequency diagram was constructe (Figure 5).

The average of the daily mean tide level is situated + 6.79 c above Curaçaos Peil. The number of data from months with ave age tide levels in the lower range is much smaller than the numb of data from months with mean tide levels in the higher range. O account of this, average value of these daily mean tide levels cann be used as the "true" mean tide level. To obtain a better estima mean tide levels were calculated for each month of the year as show in Table 2. The average of the "monthly means" in this case is 6.35 cm C.P. This may be considered the "true" mean tide level i Annabaai Harbour since the value was achieved free from the in fluence of seasonal variations of the sea level.

The seasonal variations of the sea level. The monthly mean tid levels calculated above from Table 2 show marked seasonal diffe ences. Average mean tide levels for each month of the year were ca culated by Pattullo *et al.* (1955) for a large number of stations. Th values obtained for stations on the Venezuelan coast show variation very similar to those found in Curaçao. For ready comparison, bot sets of values are plotted on the same scale in Figure 6; the Curaça values are those given in Table 2, referred to the "true" mean tide leve

In order to determine the extent of year-to-year variations, ave ages of the Curaçao mean tide levels were calculated for every sing month. During the period of seven years now in consideration th averages of individual months as given in Table 3 show large diffe



RE 4. Frequency diagram of daily tidal ranges in Annabaai Harbour over the period 1950-1956. Cf. Table 1.

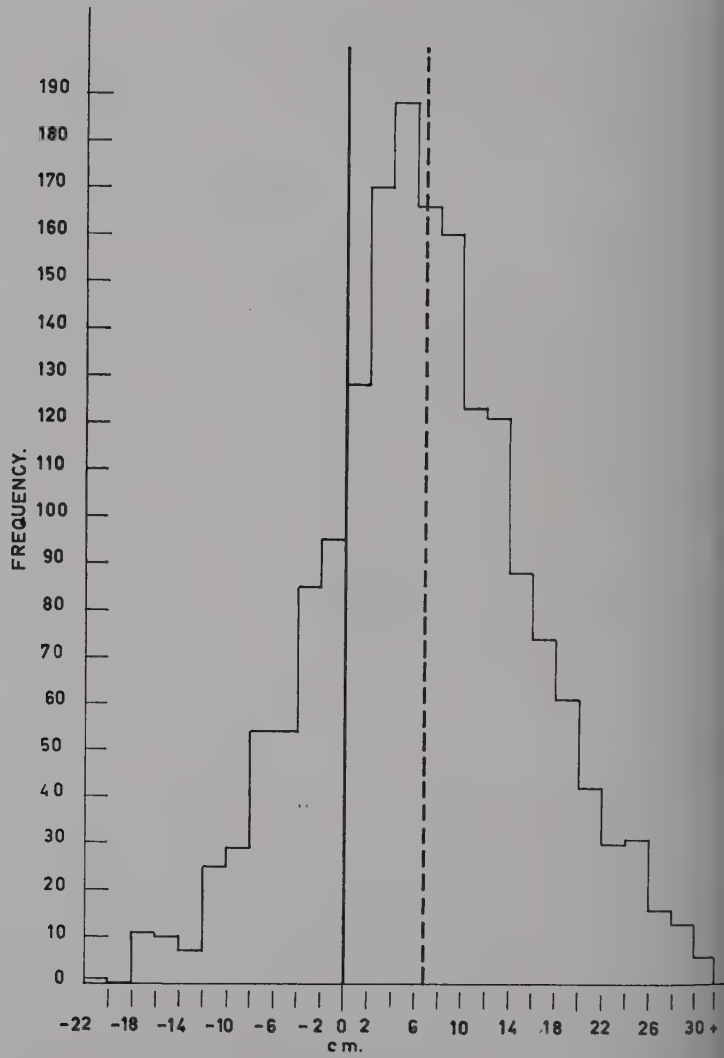


FIGURE 5. Frequency diagram of daily mean tide levels in Annabaai Harbou over the period 1950-1956. Levels are referred to "Curaçaos Peil" as datu level. The dotted line shows the average value of the daily mean tide leve Cf. Table 2.

Daily mean cm	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
+30—	—	—	—	—	—	—	—	—	—	3	3	—	6
+28—	—	—	—	—	—	—	—	—	—	9	4	—	13
+26—	—	—	—	—	—	—	—	—	3	9	4	—	16
+24—	—	—	—	1	—	—	—	2	13	8	7	—	31
+22—	—	—	—	1	—	—	2	9	9	3	5	1	30
+20—	—	—	—	6	—	—	3	3	9	2	10	9	42
+18—	—	—	—	6	7	2	8	5	6	8	11	8	61
+16—	—	—	—	2	16	2	4	8	11	4	18	9	74
+14—	—	—	2	4	5	3	10	7	19	14	13	11	88
+12—	—	1	3	4	5	10	8	11	26	24	21	8	121
+10—	1	1	4	9	12	21	11	16	15	14	9	10	123
+ 8—	7	1	8	13	19	25	14	25	16	12	10	10	160
+ 6—	12	2	7	12	17	15	25	20	10	26	8	12	166
+ 4—	14	11	13	12	21	15	27	22	19	17	6	11	188
+ 2—	12	18	9	17	15	13	23	18	14	9	13	9	170
0—	7	9	4	20	16	16	21	9	6	8	7	5	128
— 2—	13	15	13	11	13	11	2	8	1	2	4	2	95
— 4—	7	19	26	7	7	2	—	7	5	3	1	1	85
— 6—	7	10	9	11	1	6	—	6	1	1	—	2	54
— 8—	11	10	21	5	—	1	—	3	—	—	—	3	54
—10—	10	9	6	1	—	—	—	3	—	—	—	—	29
—12—	5	4	8	4	—	—	—	2	—	—	—	2	25
—14—	1	—	3	3	—	—	—	—	—	—	—	—	7
—16—	—	1	3	3	—	3	—	—	—	—	—	—	10
—18—	—	1	4	3	—	3	—	—	—	—	—	—	11
—20—	—	—	—	—	—	—	—	—	—	—	—	—	—
—22—	—	—	1	—	—	—	—	—	—	—	—	—	1
Total Month	107	112	144	155	154	148	158	184	183	176	154	113	1788
Aver. Month	—0.31	—1.64	—1.86	+3.58	+7.10	+5.39	+7.77	+7.47	+12.77	+12.49	+13.73	+9.73	

ences. Similar results were obtained by Montgomery (1938) in s level measurements on eastern U. S. coast stations.

The annual averages calculated from the single month averag are also given in Table 3. The values are subject to some dou since data from several months are lacking. Even then, it is obvio that the yearly averages vary considerably. The influence of hu ricanes passing unusually near to Curaçao in the years 1954, 19 and 1956 may have contributed to the extreme difference (16.3 cm between the averages of 1955 and 1956, although no short-ter fluctuations of importance were observed.

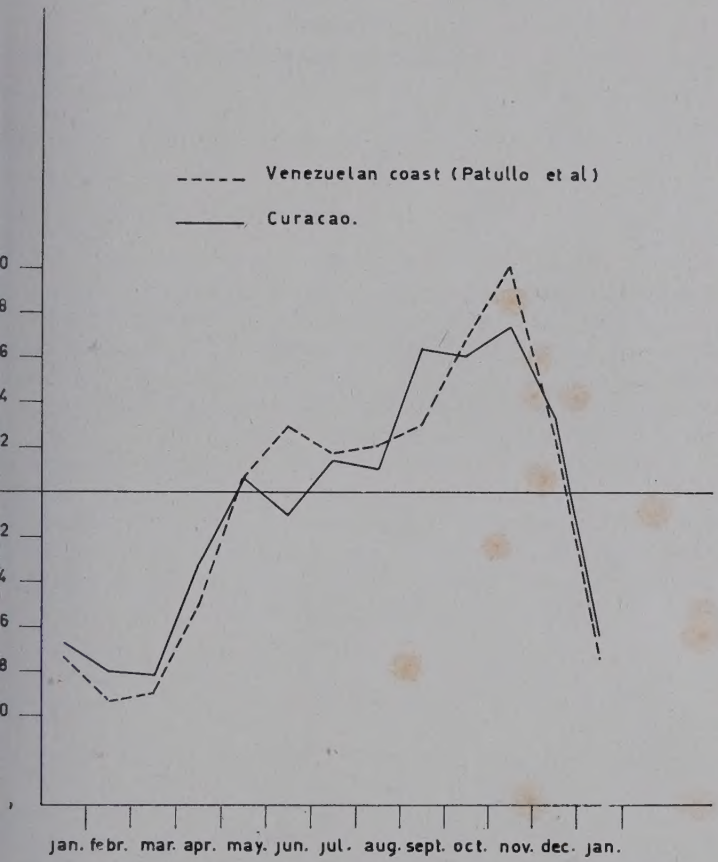
TABLE 3

MEAN TIDE LEVELS CALCULATED FOR SINGLE MONTHS. ALL VALUES ARE GIVEN IN CM AND REFER TO "CURACAOS PEIL" AS DATUM LEVEL.

Year / *Month*	1950	1951	1952	1953	1954	1955	195
January		+ 5.7		+ 2.6	— 2.0	— 6.7	
February		+ 2.0		— 6.7	+ 1.3	— 4.8	
March	— 3.4	— 3.9	— 7.1	— 1.2	+ 5.2	—12.2	+10
April		+ 0.5	0.0	+ 4.4	+ 5.6	— 6.5	+14
May		+ 8.3	+ 5.4	+ 4.9	+ 9.5	+ 4.4	+ 8
June		+ 2.3	+ 9.0	+10.0	+ 2.3	— 4.7	+ 7
July		+ 7.0	+ 6.8	+ 8.0	+ 3.1	+ 2.3	+17
August	+ 5.1	+ 5.4	+ 8.9	+ 3.4	— 4.0	+ 9.3	+18
September	+10.7	+15.5	+11.9	+10.4	+ 1.9	+ 9.1	+23
October	+ 4.2	+ 7.9	+11.3	+ 5.1	+10.7	+19.8	+26
November	+13.3	+ 3.6	+14.3	+ 2.9	+10.8	+17.8	+24
December	+12.0			+ 7.8	+ 0.4		+18
Yearly Average	+ 7.0	+ 4.9	+ 6.7	+ 4.3	+ 3.7	+ 0.7	+17

Relative time of submergence in the tidal zone. This is of impo tance with regard to the distribution of tidal organisms (Zanevel 1937). The above data were used to calculate the relative tim of submergence of different levels in the tidal zone. This calcul tion was done for the periods January-April, May-August and Se tember-December separately. Since the year-to-year variations mean tide level are very large compared with the magnitude of th daily tides, the results of these calculations cannot be used as an a proximate guide in tidal zonation.

The relative time of submergence was calculated as percentage



RE 6. Seasonal variations in mean tide level in Annabaai Harbour, Curaçao, ared with similar data for stations on the Venezuelan coast, compiled by llo *et al.* Levels are referred to "true" mean tide levels. Cf. Table 3.

time at 4 cm intervals in the tidal zone. The intervals were en arbitrarily for the convenience of computation.

rst, a "standard submergence table" was constructed with any mean tide level as zero level and giving the submergence-entage at intervals of 4 cm above and below this zero level. The iod of construction of this table was as follows: Fourteen 24-hour ods were chosen at random and assumed to be representative of

TABLE 4

"STANDARD SUBMERGENCE" TABLE.

Difference from daily mean in cm	+20	+16	+12	+8	+4	0	—4	—8	—12	—16	—20	—
% of time submerged at this level	2	4	7	17	31	45	60	74	87	93	98	

the available recordings. The hours of submergence in each peri were counted for 4 cm levels referred to the individual "daily mean from the original tide gauge recordings. The time-percentage submergence was calculated from the average number of hours su merged in the fourteen periods. The "standard submergence tabl thus obtained is given in Table 4.

Combining the frequencies of Table 2 to 4 cm intervals as show in Table 5, the contribution of each frequency group to the percen age of submergence at any given level is found by multiplication the group frequency with the appropriate value of the "standard su mergence table." The results were converted into percentages, ta ulated in Table 5 and plotted in Figure 7.

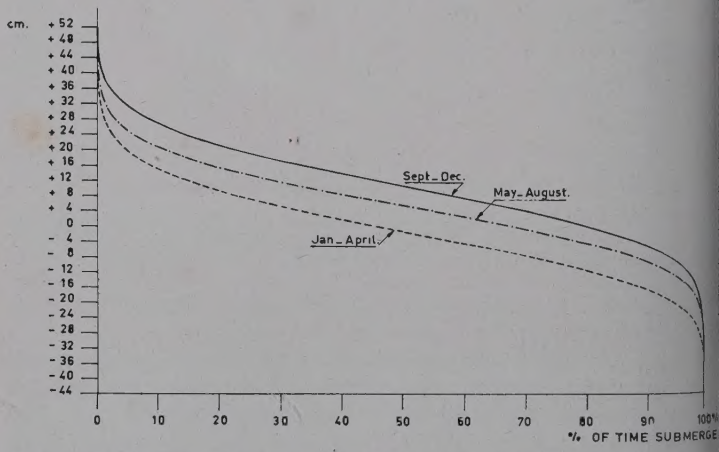


FIGURE 7. Time-percentage of submergence in tidal zone. Levels refer t "Curaçaos Peil" as datum level. Cf. Table 5.

TABLE 5

PUTATION OF TIME-PERCENTAGE OF SUBMERGENCE AT 4 CM INTERVALS

encies of daily means in 4 cm als, combined from table 2				
ly an n	*Class aver.*	*Jan. May Apr. Aug.*		*Sep. Dec.*
)—	+32			6
5—	+28			29
2—	+24	2	13	46
3—	+20	12	28	63
1—	+16	8	55	99
)—	+12	23	94	127
5—	+ 8	62	160	104
2—	+ 4	106	154	98
2—	0	92	98	35
5—	— 4	96	29	14
)—	— 8	73	7	3
1—	—12	28	2	2
3—	—16	15	6	
2—	—20	1		
l total		518	644	626

Level ref. to "C.P."	*% of time submerged* Jan. Apr.	May Aug.	Sep. Dec.
+52	0.00	0.00	0.01
+48	0.00	0.00	0.11
+44	0.01	0.03	0.36
+40	0.05	0.17	0.98
+36	0.15	0.48	2.3
+32	0.4	1.3	4.9
+28	1.0	3.0	8.9
+24	2.4	6.2	15.0
+20	4.5	11.3	23.5
+16	8.3	19.0	34.0
+12	14.4	29.6	46.0
+ 8	22.9	42.2	58.4
+ 4	33.5	55.3	70.1
0	45.7	67.9	80.2
— 4	58.4	79.0	88.0
— 8	70.3	87.6	93.6
—12	80.4	93.5	96.9
—16	88.4	97.0	98.8
—20	93.9	98.8	99.59
—24	97.1	99.55	99.88
—28	98.9	99.84	99.97
—32	99.66	99.93	99.99
—36	99.93	99.98	100.00
—40	100.00	99.99	100.00
—44	100.00	100.00	100.00

ıe method used in obtaining the "submergence" curves is essen- equivalent with the usual method of calculating "mean sea levels" veraging hourly gauge readings. Hence the "submergence" curve ides a means of estimating the "mean sea level" by taking the submergence level.

terpolating between the values of Table 5, the mean sea levels for eriods January-April, May-August and September-December, are ılated as —1.37 cm, + 5.65 cm and + 10.71 cm respectively.

ıis leads to an estimate of 1/3 (—1.37 + 6.65 + 10.71) = 00 cm for the mean sea level in the years studied.

SUMMARY OF RESULTS

) Tides in Annabaai Harbour exhibit a periodic change from ıal to semidiurnal tides. The period of the change is 13.7 days.

(b) Daily differences between the highest and lowest sea le range from 7 to 53 cm with an average daily range of 29.7 cm. T average range in the period January-April is below the yearly av age daily range, whereas the average range in the period May-Aug is above the yearly average range. The deviations are significan larger than chance variations.

(c) The "true" mean tide level in Annabaai Harbour is estimat at 6.35 cm above the currently accepted Curaçao datum level, t so-called "Curaçaos Peil."

(d) The average mean tide level is below "true" mean in t first half of the year and above "true" mean in the second half of t year. This seasonal variation is very similar to the variation found other publications for stations in the same general area.

(e) The average percentage of submergence at 4 cm intervals the tidal zone was calculated and plotted.

(f) The mean sea level in Annabaai Harbour is estimated + 5.00 cm above "Curaçaos Peil."

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